COTTON SPINNING CALCULATIONS AND YARN COSTS

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A PRACTICAL AND COMPREHENSIVE MANUAL OF CALCULATIONS, YARN COSTS, AND OTHER DATA INVOLVED IN ADAPTING THE MACHINERY IN ALL SECTIONS, AND FOR ALL GRADES, OF SPINNING AND DOUBLING

BY

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PREFACE

THE aim of the author of this work has been to provide the student with particulars of the gearing in all the machines involved in Cotton Spinning, together with a method of calculating the trains of gearing. These are accompanied by suitable examples and exercises.

Existing works containing Spinning Calculations appear to deal with this subject in a manner too abstract for the average student. In this book the details connected with the calculations and essential in changing the conditions of working, are fully given.

The effects of twist in yarn are introduced in consideration of its importance and in the hope of stimulating further investigation of its working.

The yarn costs are dealt with particularly to assist students preparing for the City and Guilds of London Institute examinations in Cotton Spinning.

MANCHESTER,
August, 1907.

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COTTON SPINNING CALCULATIONS AND COSTS OF YARN

Transmission of Motion

The Method of calculating the Rate of Motion, when Tooth Gear is employed.—When wheels are employed in a simple or direct train, as in Fig. 1, their movement, in teeth or circumferentially, is alike. Their axial movement differs only when the wheels are not alike in size. This difference is, relatively, inverse to their teeth contents. This is proved by assuming that the wheels A, B, C, and D in Fig. 1 contain 100, 75, 50, and 25 teeth, respectively, and that the first mentioned moves one revolution. Thus, the wheel A moves to the extent of 100 teeth, and since its teeth gear with those of B, and the latter with C, and these also with D, then each of them will move tooth per tooth of A, and therefore each will move 100 teeth. Hence, their respective axial movements will be—

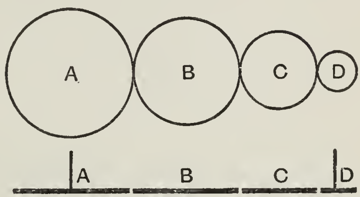


Fig. 1.

$$A = 1 \text{ or } \tfrac{100}{100} \qquad B = \tfrac{100}{75} \text{ or } 1\tfrac{1}{3}$$
$$C = \tfrac{100}{50} \text{ or } 2 \qquad D = \tfrac{100}{25} \text{ or } 4$$

The preceding results show that the axial movement or revolutions of wheels, under such conditions, are inversely proportional to their relative teeth contents, and therefore as follows :—

	Tooth contents.	Ratios of their revolutions.
A B	100 75	1 or 75 $1\frac{1}{3}$ or 100
A C	100 50	1 or 50 2 or 100
A D	100 25	1 or 25 4 or 100
B C	75 50	1 or 50 $1\frac{1}{2}$ or 75
B D	75 25	1 or 25 3 or 75
C D	50 25	1 or 25 2 or 50

The Direction of the Movement of Tooth Wheels.—In simple direct trains of wheels this is always respectively alternate. This is seen on reference to Fig. 1. By numbering the wheels in their respective numerical order, it is seen that those having odd numbers will all rotate in the same direction, and reverse to those having even numbers.

The following are examples in the application of the aforementioned points in respect of Fig. 1:—

Example I.—Assuming A revolves 100 times per minute, at what rates would B, C, and D rotate in that time?

Example II.—Assuming B revolves at the rate of 100 per minute, give the rates of A, C, and D in that time.

Example III.—Assuming C makes 100 revolutions, how many would A, B, and D make?

Example IV.—If D made 100 revolutions, how many would A, B, and C make?

Answers—

Example I.—The movement of A expressed in teeth per minute would be Revolutions of wheel × number of teeth it contains, this = 100 × 100, which

number of teeth B, C, and D must likewise move, and therefore the number of teeth moved, per minute, by B divided by the number of teeth which it contains, will give its revolutions in that time.

$$\therefore \frac{100 \times 100}{75} = 133\tfrac{1}{3} \text{ revolutions per minute of B}$$

Similarly—

$$\text{The revolutions per minute of C} = \frac{100 \times 100}{50} = 200$$

$$\text{,, \quad ,, \quad D} = \frac{100 \times 100}{25} = 400$$

Example II.—The number of teeth which B moves per minute = 100 revolutions × 75 teeth, and this number A, C, and D must consequently move, and therefore—

$$\text{The revolutions per minute of A} = \frac{100 \times 75}{100} = 75$$

$$\text{,, \quad ,, \quad C} = \frac{100 \times 75}{50} = 150$$

$$\text{,, \quad ,, \quad D} = \frac{100 \times 75}{25} = 300$$

Example III.—The number of teeth which C moves are 100 × 50, which number A, B, and D must also move, and therefore—

$$\text{The revolutions of A} = \frac{100 \times 50}{100} = 50$$

$$\text{,, \quad ,, \quad B} = \frac{100 \times 50}{75} = 66\tfrac{2}{3}$$

$$\text{,, \quad ,, \quad D} = \frac{100 \times 50}{25} = 200$$

Example IV.—The number of teeth moved by D are 100 × 25, and therefore A, B, and C will move a like number ; therefore—

$$\text{The revolutions of A} = \frac{100 \times 25}{100} = 25$$

$$\text{,, \quad ,, \quad B} = \frac{100 \times 25}{75} = 33\tfrac{1}{3}$$

$$\text{,, \quad ,, \quad C} = \frac{100 \times 25}{50} = 50$$

The Relative Rates of Rotation of the Wheels comprised in any Direct Train are respectively inverse to their Teeth Contents.—This is seen to be the case in all the preceding examples. Thus in—

Answer to Example I.—

$A : B :: 100 : 133\frac{1}{3}$, or as $1 : 1\frac{1}{3}$
$A : C :: 100 : 200$ „ $1 : 2$
$A : D :: 100 : 400$ „ $1 : 4$

Answer to Example II.—

$B : A :: 100 : 75$ „ $1\frac{1}{3} : 1$
$B : C :: 100 : 150$ „ $1 : 1\frac{1}{2}$
$B : D :: 100 : 300$ „ $1 : 3$

Answer to Example III.—

$C : A :: 100 : 50$ „ $2 : 1$
$C : B :: 100 : 66\frac{2}{3}$ „ $1\frac{1}{2} : 1$
$C : D :: 100 : 200$ „ $1 : 2$

Answer to Example IV.—

$D : A :: 100 : 25$ „ $4 : 1$
$D : B :: 100 : 33\frac{1}{3}$ „ $3 : 1$
$D : C :: 100 : 50$ „ $2 : 1$

Examples in Respect of the Direction of Rotation.—In Example I. commence by numbering A, 1; B, 2; C, 3; D, 4; thus A and C move in the opposite direction to B and D.

In Example II. commence by numbering B, 1; A, 2; C, 2; D, 3; thus A and C move reverse to B and D.

NOTE.—The reason for numbering A and C the same is because that is their relative order.

In Example III. commence by numbering C, 1; D, 2; B, 2; A, 3; thus C and A move in the opposite direction to D and B.

In Example IV. the numbering is D, 1; C, 2; B, 3; A, 4; thus D and B move in the opposite direction to C. and A.

Direct and Indirect Trains.—When wheels are arranged in an indirect train (composed of two or more simple trains), as contained in Fig. 2, the conditions of transmission differ from those obtaining in direct trains as contained in Fig. 1.

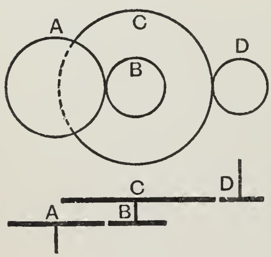


FIG. 2.

The difference in Fig. 2 consists in the wheels B and C being united and have a common axis. These must therefore revolve together. Motion from A to D is imparted to the rim of B by that of A, thence from the rim of B to its hub, and thence to the rim of C, and from this part to the rim of D.

The effects of B and C being so coupled are that their

movement in teeth is only alike when they contain the same number of teeth. Their relative movement in teeth differs in the direct ratio of their teeth contents. Thus, if in Fig. 2, A, B, C, D contain 40, 20, 60, and 20 teeth respectively—

The revolutions of	A will be to those of	B	: : 20 : 40, or as 1 : 2
,,	,,	B	,, ,,	C	: : 1 : 1
,,	,,	C	,, ,,	D	: : 20 : 60, or as 1 : 3

This shows, in two only of the three instances that the relative rotation is the inverse of their dimensions, and hence the rule, "revolutions of wheels are relatively inverse to their teeth contents," is only applicable in respect of direct trains of wheels.

Fig. 2 is an indirect train, and comprises two direct trains of wheels, namely, AB and CD. The effects of their combination may be ascertained by multiplying their separate values, together, thus—

$$2 \times 3 = 6$$

or the movement of A : D : : 1 : 6

If A, therefore, made 20 revolutions, the movement of D in revolutions would be $20 \times 6 = 120$, because A and B would move 20×40 teeth, and therefore B and C would make $\frac{20 \times 40}{20}$ revolutions, C and D would move $\frac{20 \times 40 \times 60}{20}$ teeth; and therefore the revolutions of D would be $\frac{20 \times 40 \times 60}{20 \times 20} = 120$, or the value of the train multiplied by the revolutions of its first wheel.

The following is a summary of the foregoing deductions in respect of—

Direct Trains of Wheels.—1. The circumferential or teeth rate of the movement is alike in all the wheels comprised in a direct train of wheels.

2. The rate of rotation is relatively inverse to the circumference or teeth contents of the wheels comprised in a direct train.

3. The direction of rotation is alternate at each successive wheel, and when numbered in progressive order, the direction of the odd-numbered wheels will be alike and opposite to those which are even numbered.

Indirect Trains of Wheels.—4. The circumferential or tooth rate of the movement is alike only in those wheels comprised in each of the several direct trains which constitute any indirect train.

5. The rate of rotation is relatively inverse to the tooth contents of those wheels comprised in each only of the several direct trains of which the indirect train is constituted.

6. The direction of rotation is alternate at each successive wheel in any one only of the several direct trains which constitute the indirect train.

7. **The direction of rotation** is alternate throughout an indirect train when those wheels which are fastened to each other, by a shaft or other coupling, are regarded, when numbering, as only one wheel: thus in Fig. 2 the wheels A, B, C, D would be numbered 1, 2, 2, 3 respectively, so that the direction of B and C would be that opposite to A and D.

8. The circumferential rate as well as the relative rotation, in indirect trains, is ascertained by treating them as so many simple trains as they may comprise.

Classification of Wheels.—When the function of a wheel is to convey motion from hub or axle to rim, and therefrom to another wheel, it is termed **a driver.**

When the motion is received at the rim, from another wheel, and passes thence to its hub or axle, it is designated **a driven wheel.**

When the function of a wheel is merely to convey motion along its rim from wheel to wheel, it is termed **a carrier wheel,** but when such a wheel has also to transmit movement to its hub or axle, for driving some other part, it would also be termed a driven wheel, but only in respect of the latter connection.

Examples in the Classification of wheels in Figs. 1, 2, 3—

Fig. 1, assuming the motion flowing from A to D—

A is a driver (motion flowing from the axle to rim).

B is a carrier (motion flowing merely along the rim).
C ,, ,, ,, ,,
D is a driven (motion flowing from the rim to the axle).

If the motion was from D to A then—

D would be a driver.
C ,, carrier.
B ,, ,,
A ,, driven.

Fig. 2, assuming the motion passing from A to D—

A would be a driver.
B ,, driven (the motion here passes to the axle)
C ,, driver (the motion here passes from axle to the rim).
D would be driven.

If the motion passed from D to A the above functions would be reversed.

Fig. 3, assuming the motion passed from A to E, and G—

A to E: A would be a driver.
B ,, carrier.
C ,, driven.
D ,, driver.
E ,, driven.
A to G: A and F are drivers.
B and G are driven.

Examples in respect of the direction of rotation with the motion as stated above—

Fig. 1.—A and C, their numbers respectively being 1 and 3; B and D, their numbers even 2 and 4, their direction being opposite to A and C.

Fig. 2.—A and D the same direction and positive (since their progressive numbers are, according to the definition, odd numbers positive and even numbers negative); B and C being numbered 2, 2, and therefore negative.

Fig. 3.—The numerical order of A, C, D, G, is 1, 3, 3, 3

respectively, and therefore in the positive direction; B, F, E 2, 2, and 4 respectively, and therefore negative.

The Method of calculating the Value of Wheel Trains.—A simple method, applicable in direct or indirect trains, is deduced from the foregoing procedure in ascertaining the relative movements of the wheels in Figs. 1 and 2. The value of the trains, in each of those instances, is found by **multiplying the sizes of the driver wheels, in teeth, together for a numerator, and those of the driven wheels together for a denominator**—the resultant being the value of the train; or, the relation of

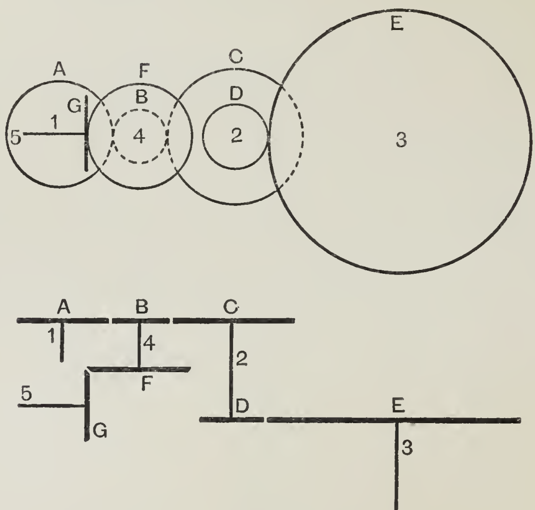


Fig. 3.

the final wheel in terms of one of the first wheel. **This result, when further multiplied by the revolutions of the first wheel, in a given time, obtains the revolutions of the final wheel in that time.**

Applying this in finding the revolutions per minute of shafts 2, 3, 4, and 5 respectively, in Fig. 3, when the sizes of the wheels in teeth, alphabetically, are: 40, 20, 50, 25, 100, 40, 30; and (1) is assumed to make 500 revolutions per minute, the following are the results :—

(1) A is a driver, B a carrier, C is a driven wheel, and therefore—

The revolutions per minute of shaft (2) $= \frac{40}{50} \times 500 = 400$

(2) A and D are drivers, B is a carrier, C and E are driven wheels, and hence—

Revolutions of shaft (3) per minute = $\frac{40}{50} \times \frac{25}{100} \times 500 = 100$

(3) Here A is a driver and B the driven wheels, therefore—

$\frac{40}{20} \times 500 = 1000$ revolutions of shaft (4) per minute

(4) Here A and F are drivers, and B and G are driven wheels, hence—

The revolutions of shaft (5) per minute $= \dfrac{40 \,.\, 40}{20 \,.\, 30} \times 500 = 1333\frac{1}{3}$

The Effects of changing Wheels.—The effects of changing the size of any wheel depends upon its function. **If a driver wheel, the axial rate of all other wheels receiving motion from it will be altered in the direct ratio of the change,** because the movement of the new wheel, in teeth, per revolution, will be altered in that ratio; and this will affect all the others depending upon it for their motion in like terms. Hence, changing A to 30, and taking the revolutions of A at 500 per minute, would cause—

The shaft (2) to rotate at—

$500 \times \frac{30}{50}$, by gear; or, by proportion:
$400 \times \frac{30}{40} = 300$ per minute

The shaft (3) to rotate at—

$500 \times \frac{30}{50} \times \frac{25}{100}$, by gear; or, by proportion:
$100 \times \frac{30}{40} = 75$ per minute

The shaft (4) to rotate at—

$500 \times \frac{30}{20}$, by gear; or, by proportion:
$1000 \times \frac{30}{40} = 750$ per minute

The shaft (5) to rotate at—

$500 \times \frac{30}{20} \times \frac{40}{30}$, by gear; or, by proportion:
$1333\frac{1}{3} \times \frac{30}{40} = 1000$ per minute

In case of a driven wheel being altered, the axial rate of those wheels, dependent upon it for their motion, would be affected in the

inverse ratio to that change.—Because the rate of movement of its teeth would be unaltered, because the wheel receives its motion from the same wheel as hitherto. Its axial rate would be increased when the new wheel contains less, and diminished if containing more, teeth. Hence, altering the wheel C to 40 instead of the wheel A, assuming the latter to make 500 revolutions per minute, would have the following results :—

Shaft (2) would rotate at—

$$500 \times \tfrac{40}{40}, \text{ or } 400 \times \tfrac{50}{40} = 500 \text{ revolutions per minute}$$

Shaft (3) would rotate at—

$$500 \times \tfrac{40}{40} \times \tfrac{25}{100} = 125 \text{ revolutions per minute}$$

Shafts (4) and (5) would not be altered.

If B were altered to 30 instead of C, then the following would be the result :—

Shafts (2) and (3) would not have their speeds affected, because C would move at the same tooth rate; thus—

Shaft (4) would rotate at—

$$500 \times \tfrac{40}{30}, \text{ or } 1000 \times \tfrac{20}{30} = 666\tfrac{2}{3} \text{ revolutions per minute}$$

Shaft (5) would rotate at—

$$500 \times \tfrac{40}{30} \times \tfrac{40}{30}, \text{ or } 1333\tfrac{1}{3} \times \tfrac{20}{30} = 888\tfrac{8}{9} \text{ revolutions per minute}$$

The foregoing show that increasing the size of a driver wheel increases proportionately the speeds of the subsequent wheels in the train, and *vice versâ*; that increasing the size of a driven wheel proportionately decreases the speeds of the subsequent wheels in the train, and *vice versâ*. Therefore, **to determine the teeth contents or size of a wheel when it is required to alter the speeds**, the procedure must be as follows :—

In the case of driver wheels: the size of the wheel it is decided to alter, multiplied by the speed required, and divided by the existing speed, will give the wheel required, because the size of this wheel must be altered in the direct proportion of the present rate to the required rate.

In case of driven wheels: the size of the wheel it is decided to alter, multiplied by the existing speed, and divided by required

speed, will give the wheel required, because the driven wheel must be altered in the inverse proportion of the present rate to the required rate.

To determine the sizes or teeth contents of wheels to employ in a train in order to obtain a specific speed of the final wheel. Ascertain the value of the train required; the distance of the shafts apart; the space available for the wheels; the pitch of the teeth that affords sufficient strength, with due regard to lightness; the direction of motion. This latter will decide whether the number of wheels to employ should be odd or even.

The number of wheels should be as few as possible. The space available restricts their size.

The distance apart of the two centres multiplied by 2(3·1416) will give the sum of the circumferences of the wheels required. This divided by the suitable pitch of the teeth gives the sum of their teeth contents, whatever the number of wheels, when they are arranged with their centres in a straight line. If their centres are arranged otherwise, it would be necessary to determine the sum of their distances apart. The latter would control the sum of their teeth contents. The contents of each wheel would then be decided according to the intermediate axial speeds required.

Under conditions similar to Fig. 2, where the ratio in the train is 6 to 1, and the latter has to rotate in the opposite direction to the former, an odd number of wheels must be employed. The following would suffice: A, six times the smallest size of D practicable, and these connected by a suitable carrier, or odd number of carriers. If there is a wide difference in the sizes of the wheels this is impracticable, then A, 2·4 times B; and C, 2·5 times D should be employed.

Exercises.—Ascertain the wheels convenient to secure the undermentioned values in the following trains:—

1. A direct train to consist of six wheels with axial motion in the ratios of 1, 2, 3, 4, 5, and 6 respectively.

2. A direct train to consist of three wheels with axial motion in the ratios of 1, $\frac{1}{3}$, and 3 respectively.

3. An indirect train of six wheels, comprising three direct trains, with the axial ratios 1, 1·6, 3·2, and 8 respectively.

4. An indirect train of six wheels, comprising three direct trains with the difference in axial ratios equally distributed, the whole amounting to 8.

5. An indirect train of six wheels, the whole containing a ratio of 1 : 9, one of the direct trains to have the value 2·08.

Rope and Belt Driving.—Ropes and belts are extensively employed in the transmission of motion. The method of calculating the speeds and sizes of the driving surfaces—pulleys and drums—is identical with that in wheel gear, the sizes of the pulleys and drums taking the place of the teeth contents in wheels; the measurements usual being in inches or feet diameter, these measurements being made from diametrically opposite points of contact of the transmitting medium.

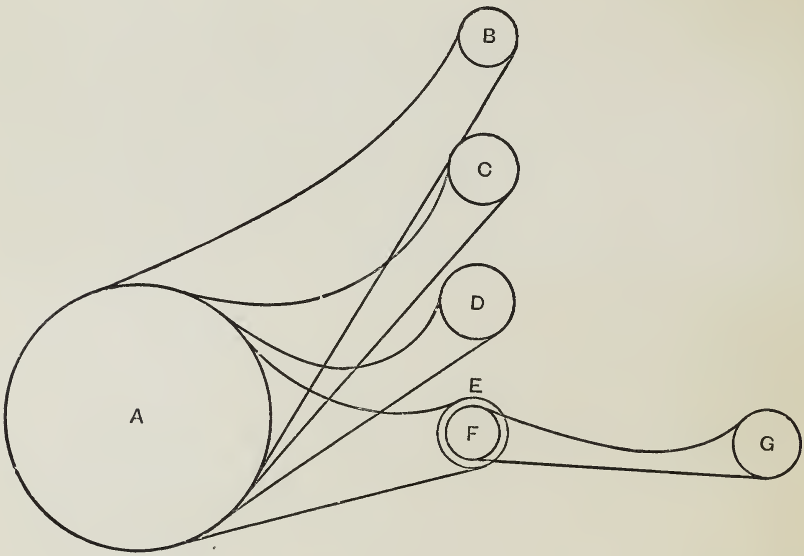


Fig. 4.

Example 1 (Fig. 4).—At what rates per minute would B, C, D, E, F, and G rotate if the grooved flywheel of the engine A makes 50 revolutions per minute, was 25 feet, and the others 5, 9, 8, 12·5, 5, and 6 feet respectively?

Answers—

$$\text{Revolutions of B per minute} = \frac{60 \times 25}{5} = 300$$

$$\text{,, C ,,} = \frac{60 \times 25}{9} = 166\tfrac{2}{3}$$

$$\text{Revolutions of D per minute} = \frac{60 \times 25}{8} = 187{\cdot}5$$

$$\text{,, E ,,} = \frac{60 \times 25}{12{\cdot}5} = 120$$

$$\text{,, F ,,} = \frac{60 \times 25}{12{\cdot}5} = 120$$

$$\text{,, G ,,} = \frac{60 \times 25 \times 5}{12{\cdot}5 \times 6} = 100$$

The reasons for adopting this method of determining the speeds of parts when motion is transmitted by belt or rope gear are as follows:—

The circumference of a drum or pulley or a circle when divided by the number 3·1416, gives its diameter; the diameter being easier to measure, it is customary to ascertain the circumference by multiplying the diameter by that number. For practical purposes $\frac{22}{7}$ is considered near enough in this kind of work.

The rate of the movement of the strap in calculating is generally assumed to be the same as the contact surface of the drum. This, however, varies considerably from that rate, according to the working conditions, such as tension, cohesiveness, and pliability of the belt; distances of the centres apart; material, sizes, and shape of drums; amount of load. These are not usually recognized in making calculations, but are allowed for in general practice.

The rate of the movement of ropes is about the same as the point of contact in well-constructed grooved pulleys. In calculating it is not customary to make any allowance.

The rate of movement of the ropes engaging with the grooved flywheel A will therefore be the same as that of the pulley at the centre of the part in contact with the rope. If this is 12·5 feet from the centre of the pulley, or equal to 25 feet in diameter, the circumference of such a circle would be 25 feet × 3·1416, and therefore this would be the rate which the rope would move per revolution of A. In 60 revolutions it would, therefore, move the rope 60 times that amount, or—

$$25' \times 3{\cdot}1416 \times 60$$

The rope moving at this rate about the pulley B, which is 5 feet diameter, or 5′ × 3·1416 in circumference, then the number of times which the length representing the circumference is contained in the length of rope passing over the pulley in a given time, will be the rate at which it revolves. Therefore—

$$\frac{25' \times 3{\cdot}1416 \times 60}{5' \times 3{\cdot}1416} = \text{the rate of rotation of B} = 300$$

Since, in rope and belt gearing, drums and pulleys always work in pairs—a driver and driven—and these in calculation are always placed on opposite sides of the equation—when one is the numerator, the other is always the denominator. The necessity for using the constant 3·1416, to convert the diameter into the circumference, occurs just as often a numerator as a denominator, and it always

cancels. It is, therefore, left out of the calculation; hence the rule is as follows:—

$$\frac{\text{diameters of drivers}}{\text{diameters of driven}} \times \frac{\text{revolutions of 1st driver}}{1} = \left\{\begin{array}{l}\text{the revolutions of the last} \\ \text{driven drum or pulley}\end{array}\right.$$

because—

$$\frac{\text{diameters of drivers} \times \text{revolutions of 1st driver}}{\text{diameters of the driven} \times \text{revolutions of last driven}} = 1$$

Example 2 (Fig. 4).—Required the revolutions per minute of F, D, C, B, A respectively, when, with the gearing as given in Example 1, G is found to revolve 110 times per minute.

Note.—It is best in working questions of this kind to assume the one moving at a known rate the driver. This always simplifies the calculation, whether dealing with rope, belt, or teeth gear.

(1) G is a driver and F driven—

$$\therefore \frac{110 \times 6}{5} = 132 \text{ revolutions of F}$$

(2) G, E, and A are drivers; F, A, and D are driven—

$$\therefore \frac{110 \times 6 \times 12{\cdot}5 \times 25}{5 \times 25 \times 8} = 206{\cdot}25 \text{ revolutions of D}$$

(3) G, E, and A are drivers; F, A, and C are driven—

$$\therefore \frac{110 \times 6 \times 12{\cdot}5 \times 25}{5 \times 25 \times 9} = 183{\cdot}\dot{3} \text{ revolutions of C}$$

(4) G, E, and A are drivers; F, A, and B are driven—

$$\therefore \frac{110 \times 6 \times 12{\cdot}5 \times 25}{5 \times 25 \times 5} = 330 \text{ revolutions of B}$$

(5) G and E are drivers; F and A are driven—

$$\therefore \frac{110 \times 6 \times 12{\cdot}5}{5 \times 25} = 66 \text{ revolutions of A}$$

Example 3 (Fig. 4).—What sizes of B, C, D, E, and F would be required in order that their revolutions per minute may be B, 250; C, 214; D, 187; E, 150; G, 100 respectively, assuming A to make 60 revolutions in that time, and to be 25′ in diameter?

Here A is the driver, and the rate of the movement of the ropes will be $60 \times 25' \times 3{\cdot}1416$ per minute.

Since B is required to revolve 250 times per minute—

$$\text{Circumference of B must be} = \frac{60 \times 25 \times 3{\cdot}1416}{250}$$

$$\text{or diameter of B} \times 3{\cdot}1416 = \frac{60 \times 25 \times 3{\cdot}1416}{250}$$

$$\therefore \text{ diameter of B} = \frac{60 \times 25 \times 3{\cdot}1416}{250 \times 3{\cdot}1416} = \frac{60 \times 25}{250} = 6'$$

Diameter of C will be—

$$\frac{60 \times 25}{214} = 7'$$

$$\text{and diameter of D} = \frac{60 \times 25}{187} = 8'$$

$$\text{and diameter of E} = \frac{60 \times 25}{150} = 10'$$

In case of F, which is also a driver—

$$\frac{60 \times 25 \times \text{diameter of F}}{\text{diameter of E} \times \text{diameter of G}} = 100 \text{ revolutions of F}$$

$$\therefore \frac{60 \times 25}{\text{diameter of E} \times \text{diameter of G}} = \frac{100}{\text{diameter of F}}$$

$$\therefore \frac{60 \times 25}{10 \times 6 \times 100} = \frac{1}{\text{diameter of F}}$$

$$\therefore \text{ diameter of F} = \frac{10 \times 100 \times 6}{60 \times 25} = 4'$$

Or, since F and G revolve 150 and 100 respectively, and G is 6 feet in diameter, and it is known that their sizes must be inversely proportional to those rates, then—

$$\frac{6' \times 100}{150} = \text{diameter of F} = 4'$$

Bale Breakers or Cotton Pullers.—Fig. 5 is an elevation of the gearing in a well-known make of machine of the Roller type. This type of machine displaced manual pulling, which was previously in vogue, in reducing the cotton to a suitable state of mixing. At present this type of machine is used extensively in old mills which do not make a point of keeping up-to-date. In modern mills a machine known as the Hopper bale breaker, or cotton puller, is found in place of the former, the disadvantages of the roller type of this machine being the dust and noise accompanied by wear and tear and frequent breakages. Its forcible action, creating heavy pressures upon the cotton between edged surfaces, are considered to exercise a

detrimental effect upon the cotton. There is a great difference in the principle of the two types of machines named. The Hopper has a coarse combing action, and considerable pressures upon the cotton are eliminated. The productive capacity of a

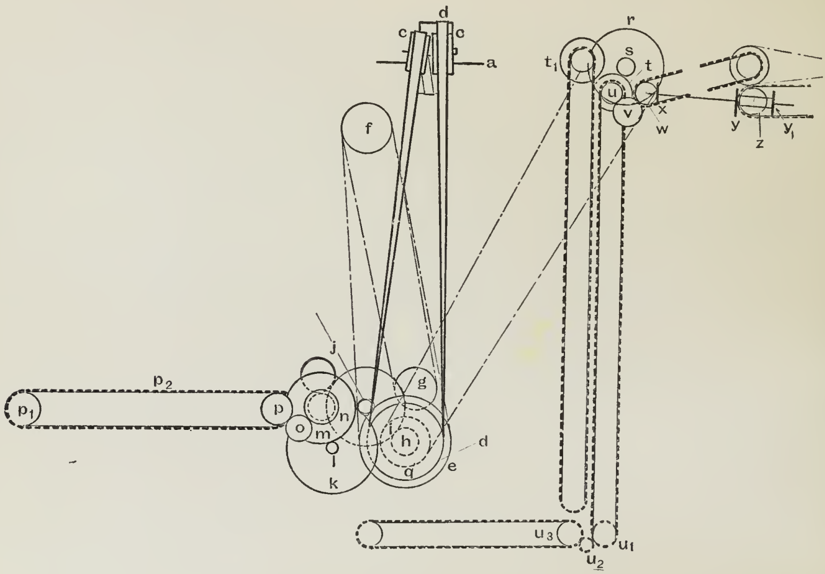


Fig. 5.

roller pulling machine ranges up to 100,000 lbs. per 55½ hours when worked at the highest pressure. The best results obtainable are when it is run at a high speed for American cotton and at a moderate speed for Egyptian and Indian varieties.

The following are the particulars of the parts in the Roller cotton puller, Fig. 5 :—

a, the line shaft making 220 revolutions per minute.

b, a drum, 19″ in diameter, on the line shaft and driving the machine strap.

c, *c* are swing or " gallows " pulleys.

d represents the fast and loose pulleys on the machine shaft; these are 16″ diameter.

e, a grooved rope pulley, 19″ diameter, fixed upon the machine shaft, driving a rope which drives the porcupine cylinder.

f, a grooved carrier pulley for the above-mentioned rope.

g, a grooved pulley, $10\frac{1}{2}''$ diameter, fixed upon the porcupine shaft and driven by the above-mentioned rope.

h, a wheel containing 25 teeth, fixed on the machine shaft.

i, a wheel on the shaft of the lower second pulling roller, containing 40 teeth, and driven by *h*.

j, a wheel containing 14 teeth, and fixed upon the axis of *i*.

k, a wheel containing 76 teeth, and driven by *j*.

l, a wheel containing 14 teeth, fixed to the axis of *k*.

m, a wheel on the lower first pulling roller, containing 76 teeth, and driven by *l*.

n, a wheel fixed on the first pulling roller, containing 17 teeth.

o, a carrier wheel, gearing with *n* and *p*.

p, a wheel on the lattice roller shaft, containing 20 teeth.

q, a grooved rope pulley, $10''$ diameter, attached to *e* and driving *r*.

r, a grooved pulley, $15''$ diameter.

s, a wheel fixed upon the axis of *r*, containing 20 teeth.

t, a wheel with 60 teeth, fixed on the lattice roller axis *u*.

t_1, a wheel with 60 teeth, fixed upon the other vertical lattice shaft and engaged with *t*.

u_1 and u_3, wheels on lattice roller shafts, each containing 38 teeth.

u_2, a carrier wheel, gearing with u_1 and u_3.

u, a wheel, 24 teeth, fixed to the lattice roller shaft.

v, a carrier wheel engaging with *u* and *w*.

w, *x*, *y*, *z*, wheels containing 24 teeth each, distributing lattice connections.

Revolutions per minute of the various parts in the roller cotton pulling machine (Fig. 5).

$$\text{The machine pulleys } \frac{220 \times 19}{16} = 261{\cdot}25$$

$$\text{The feed lattice roller } \frac{220 \times 19 \times 25 \times 14 \times 14 \times 17}{16 \times 40 \times 76 \times 76 \times 20} = 4{\cdot}7$$

$$\text{The surface speed in inches per minute } = 4{\cdot}7 \times 5{\cdot}5 \times \tfrac{22}{7} = 81''{\cdot}24$$

The first pair of pulling rollers—

$$\text{Revolutions per minute} = \frac{220 \times 19 \times 25 \times 14 \times 14}{16 \times 40 \times 76 \times 76} = 5{\cdot}53$$

$$\text{Surface speed} = \frac{220 \times 19 \times 25 \times 14 \times 14 \times 6 \times 22''}{16 \times 40 \times 76 \times 76 \qquad 7} = 113''{\cdot}76$$

The second pair of pulling rollers—

$$\text{Revolutions per minute} = \frac{220 \times 19 \times 25}{16 \times 40} = 163{\cdot}3$$

$$\text{Surface speed per minute} = \frac{220 \times 19 \times 25 \times 6 \times 22}{16 \times 40 \qquad 7} = 3079''$$

The porcupine cylinder—

$$\text{Revolutions per minute} = \frac{220 \times 19 \times 21}{16 \times 10\frac{1}{2}} = 522{\cdot}5$$

The lower conveyor lattice rollers—

$$\text{Revolutions per minute} = \frac{220 \times 19 \times 10 \times 20 \times 60}{16 \times 15 \times 60 \times 60} = 58{\cdot}05$$

Surface rate per minute in inches $58{\cdot}05 \times 5{\cdot}5 \times \frac{22}{7} = 1003''{\cdot}5$

The right-hand elevator lattice roller—

$$\frac{220 \times 19 \times 10 \times 20}{16 \times 15 \times 60} = 58{\cdot}05$$

$$\text{Surface rate} = 58{\cdot}05 \times \frac{5{\cdot}5 \times 22}{7} = 1003''{\cdot}5$$

The left-hand elevator lattice roller—

$$\frac{220 \times 19 \times 10 \times 20 \times 60}{16 \times 15 \times 60 \times 60} = 58{\cdot}05$$

The first overhead conveyor and distributing roller—

$$\frac{220 \times 19 \times 10 \times 20 \times 34}{16 \times 15 \times 60 \times 24} = 58{\cdot}05$$

$$\text{Surface rate} = 58{\cdot}05 \times \frac{5{\cdot}5'' \times 22}{7} = 1003''{\cdot}5$$

The second overhead conveyor and distributing lattice roller—

$$\frac{220 \times 19 \times 10 \times 20 \times 24 \times 24 \times 24}{10 \times 15 \times 60 \times 24 \times 24 \times 24} = 58{\cdot}05$$

$$\text{Surface rate} = 58{\cdot}05 \times 5{\cdot}5 \times \tfrac{22}{7} = 1003''{\cdot}5$$

All the machines used in connection with cotton spinning contain the power to attenuate the cotton. The term which is most generally used in place of the word attenuation is "draft." The extent of the "draft" governs the relative weight of the cotton at the different points in the processes. The extent practicable in each machine, and also between the various points in each machine, should be well understood, because it is this which governs the relation in the weight of the cotton in any part of the machine.

If a machine, or a part of it, contains a draft of four, the difference in the state of the cotton, as regards its weight, would be four times. This means that it has become four times lighter and longer between the parts referred to.

The extent of the draft may be ascertained from the relative rates of the parts moving the cotton, or, from the relation in the weight of the cotton as it passes under the influence of the two points in question.

Applying this, in respect of the machine under notice, it is found that the draft between the feed lattice and the first pair of pulling rollers is :

$$\left.\begin{array}{l}\text{surface movement}\\ \text{of the lattice per}\\ \text{minute in inches}\end{array}\right\} \rightarrow \frac{113}{81{\cdot}24} \leftarrow \left\{\begin{array}{l}\text{surface movement of the}\\ \text{first pair of pulling rollers}\\ \text{per minute in inches}\end{array}\right\} = 1{\cdot}4$$

so that the cotton under the influence of the rollers will be 1·4 times lighter than that upon the lattice, and therefore 1·4 times longer.

The following are therefore the drafts between the adjacent parts, in progressive order, in the above-named machine :—

First and second pair of pulling rollers—

$$\frac{3079}{163 \cdot 3} = 18 \cdot 85$$

Second pulling rollers and lower conveyor lattices—

$$\frac{1003 \cdot 5}{3079} = 0 \cdot 326$$

Lower conveyor and the vertical lattices—

$$\frac{1003 \cdot 5}{1003 \cdot 5} = 1$$

Feed lattice and overhead conveyor lattice—

$$\frac{1003 \cdot 5}{81 \cdot 24} = 12 \cdot 35$$

Exercise 1.—What would be the speeds, in revolutions per minute, of the under-mentioned parts, if the line-shaft driving drum was 16 inches in diameter instead of 19 inches: (*a*) the machine pulley; (*b*) the feed lattice roller; (*c*) the first pair of pulling rollers; (*d*) the second pair of pulling rollers; (*e*) the porcupine cylinder; (*f*) the lower conveyor lattice roller; (*g*) the vertical conveyor lattice rollers; (*h*) the overhead conveyor lattice rollers?

Exercise 2.—What would be the effect upon the speeds of the different parts if the 25 wheel on the machine shaft was changed to 30 after changing the line-shaft drum to 16 inches?

The working of the first of these exercises is as follows:—

(*a*) $$\frac{220 \times 16}{16} = 220$$

(*b*) $$\frac{220 \times 25 \times 14 \times 14 \times 17}{40 \times 76 \times 76 \times 20} = 3 \cdot 966$$

or, by proportion $\frac{4 \cdot 7 \times 16}{19} = 3 \cdot 96$

(*c*) $$\frac{220 \times 25 \times 14 \times 14}{40 \times 76 \times 76} = 4 \cdot 66; \text{ or } \frac{5 \cdot 53 \times 16}{19} = 4 \cdot 66$$

(*d*) $$\frac{220 \times 25}{40} = 137 \cdot 5; \text{ or } \frac{163 \cdot 3 \times 61}{19} = 137 \cdot 5$$

(*e*) $$\frac{220 \times 21}{10\frac{1}{2}} = 440; \text{ or } \frac{522 \cdot 5 \times 16}{19} = 440$$

(*f*) $$\frac{220 \times 10 \times 20 \times 38}{15 \times 60 \times 38} = 48\tfrac{8}{9}; \text{ or } \frac{58 \cdot 05 \times 16}{19} = 48 \cdot 89$$

(g) $\frac{220 \times 10 \times 20}{15 \times 60} = 48\frac{8}{9}$; or $\frac{58{\cdot}05 \times 16}{19} = 48{\cdot}89$

(h) $\frac{220 \times 10 \times 20 \times 24}{15 \times 60 \times 24} = 48\frac{8}{9}$; or $\frac{58{\cdot}05 \times 16}{19} = 48{\cdot}89$

Answers to Exercise 2—

(a) Machine pulleys, 220.
(b) 4·759.
(c) 5·57.
(d) 165.
(e) 440.
(f) 48·89.
(g) 48·89.

Fig. 6 is an elevation of the gearing in a cotton pulling machine of the Hopper type. This type of machine reduces the

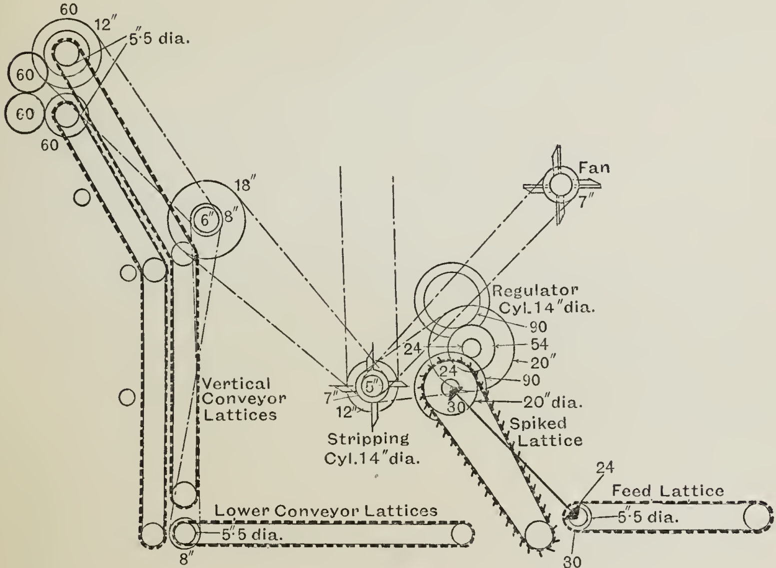


Fig. 6.

cotton to a very loose open condition. The advantages of this machine over the roller type of machine are—

Greater opening and cleaning power.

Less noise and dust when well constructed.

Less personal attention.

Greater production, about 200,000 lbs. per $55\frac{1}{2}$ hours, without pressure.

Less risks of fire in this and subsequent machines by its eliminating hard substances.

Mixing powers considerable, whereas in the roller type they are very limited.

Fewer breakages and up-keep less costly.

The machine driving pulleys are on the stripping cylinder shaft, and in the figure they are shown as 12 inches in diameter. These are driven by a strap from a drum on the line shaft, 26 inches in diameter, and making 220 revolutions per minute.

(1) Revolutions per minute of the fast and loose drums of the machine—

$$\frac{220 \times 26}{12} = 476\tfrac{2}{3}$$

(2) Revolutions per minute of the supply lattice roller—

$$\frac{220 \times 26 \times 7 \times 24 \times 24 \times 24}{12 \times 20 \times 90 \times 30 \times 30} = 29{\cdot}36$$

(3) Rate per minute in feet—

$$\frac{29{\cdot}36 \times 5{\cdot}5 \times 22}{12 \times 7} = 42'$$

(4) Revolutions per minute of the spiked lattice roller—

$$\frac{220 \times 26 \times 7 \times 24}{12 \times 20 \times 90} = 44{\cdot}49$$

(5) Surface rate per minute—

$$\frac{44{\cdot}49 \times 20 \times 22}{12 \times 7} = 233'$$

(6) Revolutions per minute of the regulating cylinder—

$$\frac{220 \times 26 \times 7 \times 54}{12 \times 20 \times 90} = 100{\cdot}1$$

(7) Surface rate—

$$\frac{100{\cdot}1 \times 14 \times 22}{12 \times 7} = 376'$$

(8) Revolutions per minute of the stripping cylinder—

$$\frac{220 \times 26}{12} = 476\tfrac{2}{3}$$

(9) Surface rate—

$$\frac{476\frac{2}{3} \times 14 \times 22}{12 \times 7} = 1747'\cdot 5$$

(10) Revolutions per minute of the lower conveyor lattice roller—

$$\frac{220 \times 26 \times 7 \times 8}{12 \times 18 \times 8} = 185\cdot 37$$

(11) Surface rate—

$$\frac{185\cdot 37 \times 5\cdot 5 \times 22}{12 \times 7} = 267'$$

(12) Revolutions per minute of the elevating lattice rollers—

$$\frac{220 \times 26 \times 7 \times 6}{12 \times 18 \times 12} = 92\cdot 7$$

(13) Surface rate—

$$\frac{92\cdot 7 \times 5\cdot 5 \times 22}{12 \times 7} = 133'\cdot 5$$

Exercise 3.—At what rates, in revolutions and feet per minute, would each of the parts in Fig. 6 rotate if the driving pulleys were altered to 15 inches diameter, instead of 12 inches?

Exercise 4.—Ascertain the drafts between the different lattices when the conditions are as given in Fig. 6, and also when the machine pulleys are altered to 15 inches?

Exercise 5.—State the effects of changing the 24 wheel, driving the 90, to 20, upon the speed of each part, when the other conditions are as given in Fig. 6.

Answers to Exercise 3—

(1) 381·3 revolutions.
(2) and (3) 23·5 and 36·6 feet.
(4) „ (5) 35·6 „ 186·4 „
(6) „ (7) 80·0 „ 300·8 „
(8) and (9) 381·3 and 1398 feet.
(10) „ (11) 148·3 „ 213·62 „
(12) „ (13) 74·1 „ 106·8 „

Answers to Exercise 4—

When the driving pulleys are 12 inches diameter, the draft between feed and spiked lattice is 5·55.

When the driving pulleys are 12 inches diameter, the draft between spiked lattice and the lower conveyor lattice is 1·16.

When the driving pulleys are 12 inches diameter, the draft between lower conveyor and elevating lattices is 0·5.

When the driving pulleys are 15 inches diameter, the speed of all the parts will be decreased in the same proportion, and the drafts will therefore be unaltered.

Answers to Exercise 5—

(1)	$476\frac{2}{3}$ revolutions.		(8) and (9)	Unaltered.
(2) and (3)	24·46 ,,	; 35 feet.	(10) ,, (11)	,,
(4) ,, (5)	37 ,,	194 feet.	(12) ,, (13)	,,
(6) ,, (7)	83·4 ,,	313 3 feet.		

The usefulness of this machine is infinitely greater than the roller puller. Evidence of this is found in the number of mills which have modified their mixing arrangements since its introduction.

The most common practice in using this machine is that of placing the cotton from the various lots of bales in the machine, in the desired proportions, at a rate permitting only of the limited exercise of their opening and mixing functions. When such replaces stack mixing, variations are visible in all the subsequent stages.

Extension in the usefulness of the machine is possible by adopting one puller per 30,000 or 40,000 lbs. per week, and adjusting them so that their maximum opening capacities are utilized in that time, the cotton, from the several pullers, supplied with bale cotton in the usual way but in perfect rotation, passing into a common trunk, from which the several exhaust openers draw their supplies. These latter deliver to hopper feeders attached to further openers, fitted with the full width type of beaters. From these the cotton may pass to the scutcher or to the card direct. The hopper feeder to the final opener should be fitted with automatic supply control attached to feed of the opener responsible for its supply. By this system, in a mill consuming 200,000 lbs. of cotton per week, the supply would be drawn from six times the usual number of bales, with the additional advantages that the hard and soft qualities would be unavoidably mixed in the designed proportions continuously.

To derive the fullest benefits from the use of the hopper

cotton puller—as an opening process—it is necessary to bear in mind that the opening, and consequently the cleaning effect, is dependent upon: The rate of movement of the spikes amongst the cotton and the pressure of the cotton against the spiked surfaces; the distance of the points of the spikes on the regulating cylinder from those on the spiked lattice, and the contrasting rates in the movement of these two latter parts.

The best speed of the spiked lattice is the highest rate at which it may be worked without undue strain. The rate varies considerably in the various makes, and also with cotton treated. American cotton allows of a higher rate than Indian or Egyptian. The most beneficial speed can be readily ascertained by test. This decided, the regulating cylinder should be adjusted to a point at which the machine produces only the amount of cotton required in the full working time. Where these items are disregarded the opening and cleaning utility of the machine is only partially realized.

The Opener.

Fig. 7 contains particulars of the principal parts and their connections in a hopper-fed compound combined opener. Particulars of the other parts and their connections are contained in Figs. 8, 9, 10, and 11. The object of giving the details in five instead of in one figure is to avoid confusion.

The speeds of the various parts in Fig. 7 are—

Counter shaft	495	revolutions per minute
Beater shaft	1028	,, ,,
Cross shaft	214·17	,, ,,
Side shaft	428·34	,, ,,
Bottom cone shaft . . .	856·73	,, ,,
Top cone shaft	611·95	,, ,,
Porcupine cylinder . . .	440	,, ,,
Fan shaft (1)	1015·4	,, ,,
Fan shaft (2)	1542	,, ,,

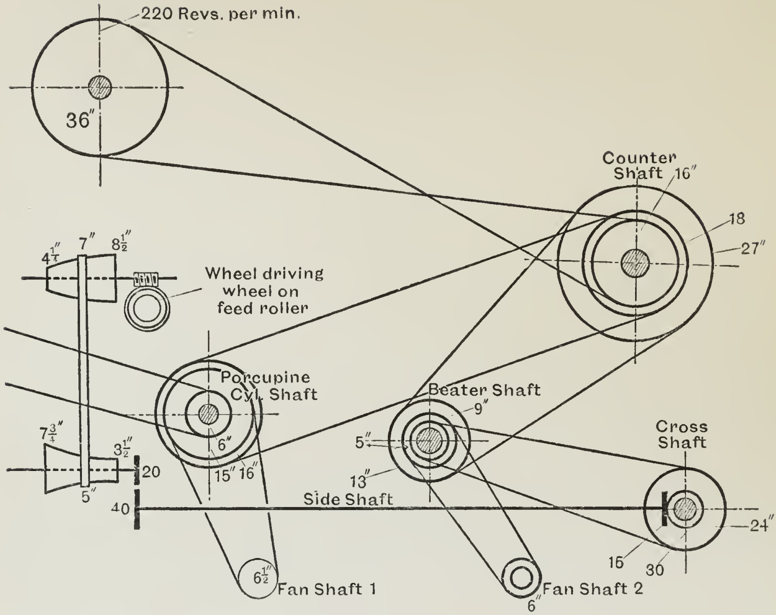


FIG. 7.

EXAMPLES OF WORKING OUT THE SPEEDS OF THE ABOVE PARTS.

The counter shaft $= \frac{220 \times 36}{16} = 495$

The beater ,, $= \frac{220 \times 36 \times 27}{16 \times 13} = 1028$

The cross ,, $= \frac{220 \times 36 \times 27 \times 5}{16 \times 13 \times 24} = 214 \cdot 17$

The side ,, $= \frac{220 \times 36 \times 27 \times 5 \times 30}{16 \times 13 \times 24 \times 15} = 428 \cdot 34$

The bottom cone $= \frac{220 \times 36 \times 27 \times 5 \times 30 \times 40}{16 \times 13 \times 24 \times 15 \times 20} = 856 \cdot 73$

The top ,, $= \frac{220 \times 36 \times 27 \times 5 \times 30 \times 40 \times 5}{16 \times 13 \times 24 \times 15 \times 20 \times 7} = 611\ 95$, say 612

The porcupine cylinder $= \frac{220 \times 36 \times 18}{16 \times 16} = 557$

Fan shaft (1) $= 557 \times \frac{15}{6\frac{1}{2}} = 1285$

Fan shaft (2) $= 1028 \times \frac{9}{6} = 1542$

Exercises relating to Fig. 7.

(1) At what speeds would the parts contained in this figure revolve if the line shaft made 250 instead of 220 revolutions per minute?

(2) If the fan-shaft pulley (1) was changed to 6 inches, at what rate per minute would it revolve?

(3) At what rate per minute would the bottom and top cones revolve if the bottom cone and side-shaft wheels, 20 and 40, were substituted by 24 and 36 respectively?

(4) What size of driving and driven pulleys would alter the rate of the cross shaft from 214·17 to 257 per minute? What effect would such an alteration have upon the speeds of the other parts?

(5) What changes would alter the speed of the beater to 1113 revolutions per minute if the fan and cross shaft are to remain unaltered?

(6) At what rates would the top-cone shaft revolve when the cone strap is working on the extreme right and left ends respectively?

Answers to Exercises (Fig. 7)—

(1) The speed of all the parts would be increased in the same proportion as the change in speeds, thus: 562, 1168, 243·3, 486·7, 973·5, 684, 500, 1153·8, 1752 respectively.

(2) The surface rate of the strap and pulley would be unaltered, and therefore the revolutions per minute would be altered in same proportion as the size of pulley, namely, to 1100.

(3) Bottom cone, 458·9; top cone, 645.

(4) A 6-inch driver on the beater shaft, or a 20-inch driven on the cross shaft. The side shaft and bottom and top cones would be altered in the ratio of from 5 to 6, or to 514, 1028, and 734 respectively.

(5) The beater pulley to 13 inches; the pulley driving the cross-shaft pulley $4\frac{8}{13}$ inches, or the cross-shaft pulley 26 inches; the pulley on fan shaft $6\frac{1}{2}$ inches.

(6) 1562 and 352·7 respectively.

Calculations relating to the speeds of the parts in Fig. 8.

Revolutions per minute of—

$$\text{The supply lattice roller} = \frac{612 \times 4 \times 9 \times 1 \times 12}{9 \times 7 \times 78 \times 85} = 0{\cdot}633$$

$$\left.\begin{array}{r}\text{The surface speed in}\\ \text{inches per minute}\end{array}\right\} = \frac{0{\cdot}633 \times 5{\cdot}5 \times 22}{7} = 10{\cdot}94$$

$$\left.\begin{array}{l}\text{The bottom lattice rollers}\\ \text{in the hopper}\end{array}\right\} = \frac{612 \times 4 \times 23 \times 17 \times 20 \times 20}{9 \times 55 \times 79 \times 48 \times 48} = 4{\cdot}25$$

$$\left.\begin{array}{r}\text{The surface speed in}\\ \text{inches per minute}\end{array}\right\} = \frac{4{\cdot}25 \times 5{\cdot}5 \times 22}{7} = 73{\cdot}5$$

$$\left.\begin{array}{r}\text{The spiked lattice rollers}\\ \text{in the hopper}\end{array}\right\} = \frac{612 \times 4 \times 23 \times 17}{9 \times 55 \times 79} = 24{\cdot}47$$

$$\left.\begin{array}{r}\text{The surface speed in}\\ \text{inches per minute}\end{array}\right\} = \frac{24{\cdot}47 \times 5{\cdot}5 \times 22}{7} = 422{\cdot}98$$

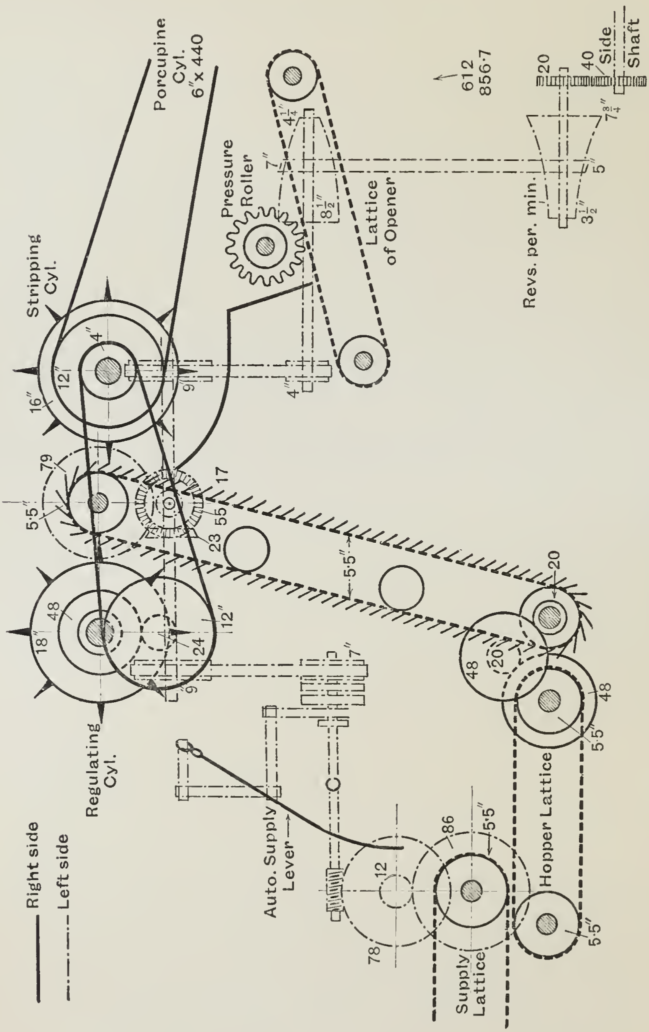


Fig. 8.

$$\text{The regulating cylinder} = \frac{440 \times 6 \times 4 \times 24}{12 \times 12 \times 48} = 36{\cdot}6$$

$$\left.\begin{array}{r}\text{The surface speed in}\\ \text{inches per minute}\end{array}\right\} = \frac{330 \times 18'' \times 22}{9 \qquad\qquad 7} = 2074'', \text{or } 172{\cdot}8 \text{ ft.}$$

$$\text{The stripping cylinder} = \frac{440 \times 6}{12} = 220$$

$$\left.\begin{array}{r}\text{The surface speed in}\\ \text{inches per minute}\end{array}\right\} = \frac{220 \times 16 \times 22}{7} = 11063'', \text{or } 921{\cdot}9 \text{ ft.}$$

Questions relating to Fig. 8.

Name the parts affected by each of the following alterations, and calculate the effects in revolutions and surface speed in feet per minute:—

(7) If the cone strap was successively placed at both extreme points on the cone drums.

(8) If the pulley on the top-cone shaft was 5 inches diameter instead of 4.

(9) If the pulley on C was changed to 9 inches diameter.

(10) If the 86 on the supply lattice roller shaft and the 12 driving it were altered to 84 and 14 respectively.

Answers to questions relating to Fig. 8—

(7) When the strap occupies—

	The left-hand extreme position.	The right-hand extreme position.
Spiked lattice roller . .	14·1 revolutions	62·5 revolutions
" " . .	244 feet	1238 feet
Hopper lattice roller . .	2·45 revolutions	10·84 revolutions
" " . .	42·3 feet	187·6 feet
Supply lattice roller . .	0·358 revolutions	1·615 revolutions
" " . .	6·3 feet	27·9 feet

(8) The parts affected would in this case be the same as in question 7, each being increased in rate to the extent of $\frac{5}{4}$, or—

Spiked lattice roller	30·58 revolutions
" "	528·72 feet
Hopper lattice roller	5·31 revolutions
" "	91·8 feet
Supply lattice roller	0·791 revolutions
" "	13·67 feet

(9) In this case only the supply lattice would be affected, and this to the extent of $\frac{7}{9}$; thus—

Revolutions of supply lattice roller	0·492
Surface speed	8·5 feet

(10) In this instance only the supply lattice would be affected, and this to the extent of $\frac{86}{84} \times \frac{14}{12}$, and therefore—

Revolutions of supply lattice roller = 0·756
Surface speed = 13·67

Calculations relating to the speed of the parts found in Fig. 9.

Revolutions per minute of—

$$\text{The lattice roller} = \frac{612 \times 1 \times 34 \times 27 \times 17}{62 \times 40 \times 33 \times 20} = 5{\cdot}835$$

$$\left.\begin{array}{r}\text{The surface speed of}\\ \text{the lattice in inches}\end{array}\right\} = \frac{5{\cdot}835 \times 3'' \times 22}{7} = 55{\cdot}015$$

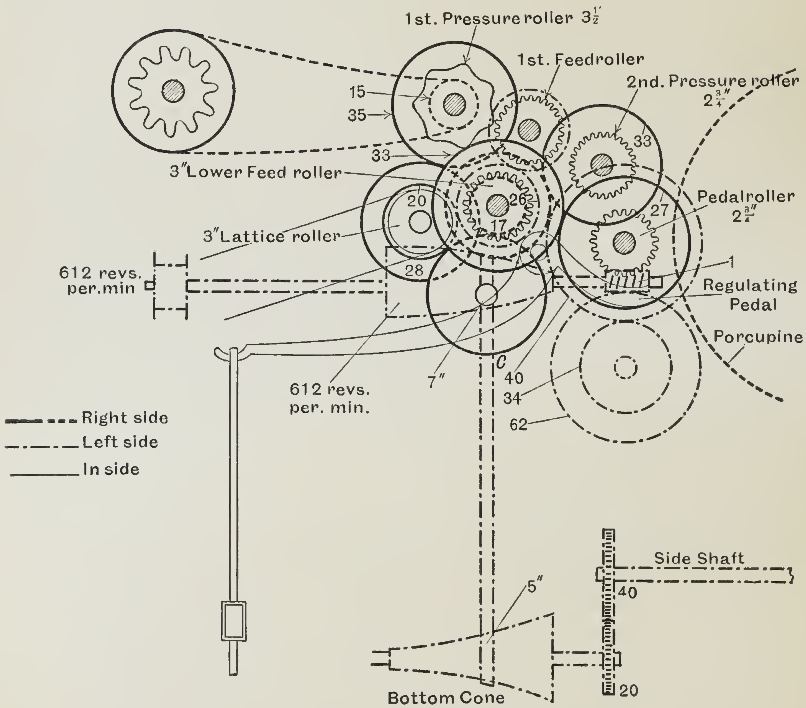


FIG. 9.

$$\text{The first presser roller} = \frac{612 \times 1 \times 34 \times 27 \times 17 \times 28}{62 \times 40 \times 33 \times 20 \times 35} = 4{\cdot}667$$

$$\left.\begin{array}{r}\text{The surface speed of the}\\ \text{first presser roller in ins.}\end{array}\right\} = \frac{4{\cdot}667 \times 3{\cdot}5'' \times 22}{7} = 51{\cdot}337$$

$$\text{The lower feed roller} = \frac{612 \times 1 \times 34 \times 27}{62 \times 40 \times 33} = 6{\cdot}865$$

$$\left.\begin{array}{r}\text{The surface speed in}\\ \text{inches per minute}\end{array}\right\} = \frac{6{\cdot}865 \times 3'' \times 22}{7} = 64{\cdot}7$$

$$\text{The second presser roller} = \frac{612 \times 1 \times 34 \times 27 \times 26}{62 \times 40 \times 33 \times 33} = 7{\cdot}76$$

$$\left.\begin{array}{r}\text{The surface speed in}\\ \text{inches per minute}\end{array}\right\} = \frac{7{\cdot}76 \times 2\tfrac{3}{4}'' \times 22}{7} = 67$$

$$\text{The pedal roller} = \frac{612 \times 1 \times 34}{62 \times 40} = 8{\cdot}358$$

$$\left.\begin{array}{r}\text{The surface speed in}\\ \text{inches per minute}\end{array}\right\} = \frac{8{\cdot}4 \times 2\tfrac{3}{4}'' \times 22}{7} = 72{\cdot}01$$

Questions relating to Fig. 9.

(11) What would be the effect of changing—

(*a*) The 17 on the lower feed roller to 16 ?
(*b*) The 27 on the pedal roller to 32 ?
(*c*) The cone strap to the extreme left on the cones, if their diameters at those points were—bottom, $3\frac{1}{2}$; top, $8\frac{1}{2}$?

Answers to questions relating to Fig. 9—

(11) (*a*) The rate of the lattice roller would be reduced to—

Revolutions per minute.	Surface speed in feet per minute.
5·592	52·95

(*b*) All the parts dependent upon the 27 wheel for their motion would be affected directly as the change, namely—

	Revolutions per minute.	Surface speed per minute.
The lower feed roller to	8·136	76·68
,, lattice roller to	6·916	65·27
,, first presser roller to . . .	5·531	60·84
,, lower feed roller to	8·136	76·68
,, second presser roller to . .	9·19	79·4

(*c*) Each of the rollers in Fig. 9 would have their speed changed to $\frac{3\frac{1}{2}}{5} \times \frac{7}{8\frac{1}{2}} \times$ speed of part when the strap is in central position.

Calculations relating to the speeds of the parts found in Fig. 10, *the driving of the beater being as given in Fig.* 7.

Revolutions and surface speed per minute of—

$$\left.\begin{array}{r}\text{Top side}\\ \text{shaft}\end{array}\right\} = \frac{220 \times 36 \times 27 \times 5 \times 13 \times 13 \times 24}{16 \times 13 \times 24 \times 65 \times 38 \times 24} = \frac{4455}{304} = 14{\cdot}62$$

$$\left.\begin{array}{r}\text{Bottom}\\ \text{cage}\end{array}\right\}=\frac{220\times 36\times 27\times 5\times 13\times 13\times 24\times 24\times 40\times 14\times 44}{16\times 13\times 24\times 65\times 38\times 24\times 30\times 28\times 44\times 115}$$

$$=\frac{498960}{2128.115}=2\cdot 039$$

$$\left.\begin{array}{r}\text{Surface}\\ \text{speed}\end{array}\right\}=\frac{2\cdot 039\times 16''\times 22}{7}=102''\cdot 53$$

$$\text{Top cage}=\frac{220\times 36\times 27\times 5\times 13\times 13\times 24\times 24\times 40\times 14\times 44}{16\times 13\times 24\times 65\times 38\times 24\times 30\times 28\times 44\times 151}$$

$$=\frac{498960}{321328}=1\cdot 5528$$

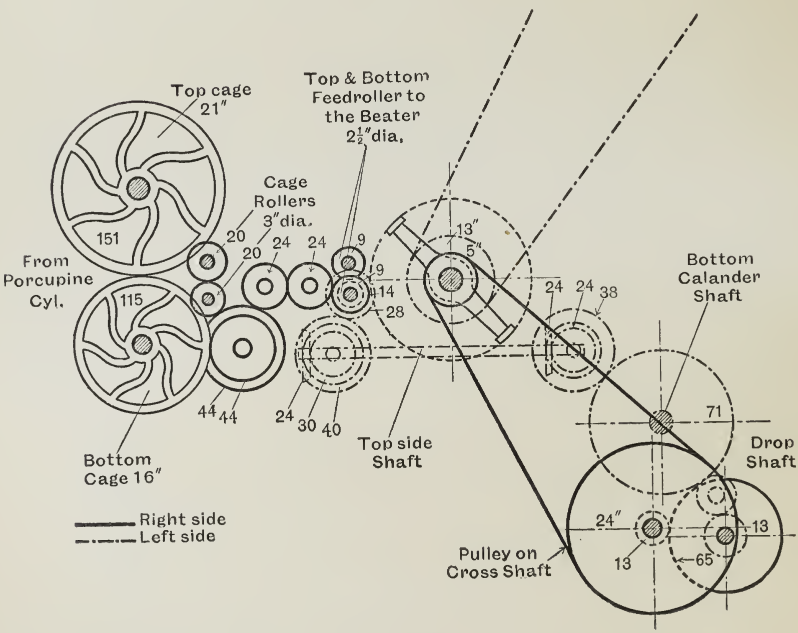


Fig. 10.

$$\left.\begin{array}{r}\text{Surface}\\ \text{speed}\end{array}\right\}=\frac{1\cdot 5528\times 21''\times 22}{7}=102''\cdot 485$$

$$\left.\begin{array}{r}\text{Cage}\\ \text{rollers}\end{array}\right\}=\frac{220\times 36\times 27\times 5\times 13\times 13\times 24\times 24\times 40\times 14}{16\times 13\times 24\times 65\times 38\times 24\times 30\times 28\times 20}$$

$$=\frac{17820}{1520}=11\cdot 72$$

$$\left.\begin{array}{r}\text{Surface}\\ \text{speed}\end{array}\right\}=\frac{11{\cdot}72\times3''\times22}{7}=110''{\cdot}5$$

$$\left.\begin{array}{l}\text{Bottom}\\ \text{feed roller}\end{array}\right\}=\frac{220\times36\times27\times\ 5\ \times13\times13\times24\times24\times40}{16\times13\times24\times65\times38\times24\times30\times28}$$

$$=\frac{35640}{2128}=16{\cdot}75$$

$$\left.\begin{array}{r}\text{Surface}\\ \text{speed}\end{array}\right\}=\frac{16{\cdot}75\times2\tfrac{1}{2}''\times22}{7}=131''{\cdot}6$$

Exercises in Connection with Fig. 10.

What would be the effects if—

(*a*) The 44 wheel driving the bottom cage wheel was changed to 46?

(*b*) The 14 wheel on the bottom feed roller was changed to 16?

(*c*) The 24 wheel on the side shaft was changed to 22?

Ascertain the wheels that would make the surface speeds of cages, cage rollers, and feed rollers as nearly alike as practicable without altering the rate of the latter.

Calculations relating to the speeds of the parts found in Fig. 11.

Revolutions and surface speed per minute of—

$$\text{The top cage}=\frac{220\times36\times27\times\ 5\ \times13\times13\times27\times25\times\ 33}{16\times13\times24\times65\times71\times21\times25\times151}$$

$$=2{\cdot}203$$

$$\text{Surface speed}=\frac{2{\cdot}203\ \times\ 21''\ \times\ 22}{7}=145''{\cdot}45$$

$$\text{The bottom cage}=\frac{220\times36\times27\times\ 5\ \times13\times13\times27\times25\times\ 33}{16\times13\times24\times65\times71\times21\times25\times115}$$

$$=2{\cdot}893$$

$$\text{Surface speed}=\frac{2{\cdot}893\times16''\times22}{7}=145''{\cdot}51$$

$$\text{The cage rollers}=\frac{220\times36\times27\times\ 5\ \times13\times13\times27\times25}{16\times13\times24\times65\times71\times21\times16}$$

$$=15{\cdot}756$$

$$\text{Surface speed}=\frac{15{\cdot}756\times3''\times22}{7}=148''{\cdot}55$$

$$\left.\begin{array}{l}\text{First or the top}\\ \text{calender}\end{array}\right\}=\frac{220\times36\times27\times\ 5\ \times13\times13\times27}{16\times13\times24\times65\times71\times23}=9{\cdot}207$$

$$\text{Surface speed}=\frac{9{\cdot}207\times5''{\cdot}5\times22}{7}=159''{\cdot}15$$

$$\text{The second calender} = \frac{220 \times 36 \times 27 \times 5 \times 13 \times 13 \times 27}{16 \times 13 \times 24 \times 65 \times 71 \times 22} = 9{\cdot}626$$

$$\text{Surface speed} = \frac{9{\cdot}626 \times {}''5{\cdot}5 \times 22}{7} = 166''{\cdot}39$$

$$\text{The third calender} = \frac{220 \times 36 \times 27 \times 5 \times 13 \times 13 \times 27}{16 \times 13 \times 24 \times 65 \times 71 \times 21} = 10{\cdot}084$$

$$\text{Surface speed} = \frac{10{\cdot}084 \times 5''{\cdot}5 \times 22}{7} = 174''{\cdot}30$$

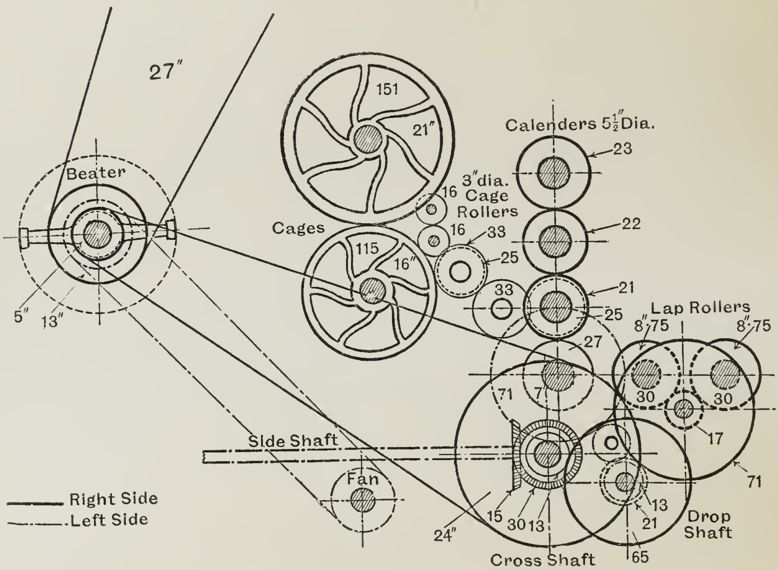


FIG. 11.

$$\left.\begin{array}{r}\text{The fourth or}\\ \text{bottom calender}\end{array}\right\} = \frac{220 \times 36 \times 27 \times 5 \times 13 \times 13}{16 \times 13 \times 24 \times 65 \times 71} = 7{\cdot}843$$

$$\text{Surface speed} = \frac{7{\cdot}843 \times 7'' \times 22}{7} = 172''{\cdot}55$$

$$\text{The lap rollers} = \frac{220 \times 36 \times 27 \times 5 \times 13 \times 21 \times 17}{16 \times 13 \times 24 \times 65 \times 71 \times 30} = 7{\cdot}179$$

$$\text{Surface speed} = \frac{7{\cdot}179 \times 8\tfrac{3}{4}'' \times 22}{7} = 197''{\cdot}42$$

Drafts in Openers.—In the processes embraced in spinning the cotton is attenuated in a somewhat graduated manner, until

it is reduced to a specific weight per unit of length; the extent of the attenuation applied, in each as well as in the collective processes, depending upon the ultimate fineness or count of the yarn required. The attenuation is increased with the fineness of the yarn, and it is distributed amongst the various machines in proportions which practice has proved most beneficial. A knowledge of the extent most expedient in each process, as well as between the various points in each process, is therefore indispensable.

"Draft" is the term used to denote the attenuation or difference taking place in the unit of weight of the cotton in the various stages. It is used also in expressing the difference in the rate of movement of the parts of a machine. It denotes the amount of attenuation occurring between two points, which it is customary to express in terms of one unit of the preceding of the two points specified. Thus if the draft in an opener is said to be three, the rate of the delivery in terms of one unit of the feed is three, and therefore the cotton is elongated to an extent of three times its original length, and in consequence becomes at least one-third of the weight per unit of length fed.

The several ways of proceeding to ascertain the amount of the draft are—

(*a*) By timing the rate of movement of the respective parts.

(*b*) By comparing the weight of the cotton per unit of length at the respective parts.

(*c*) By calculating the relative movement of the respective parts by means of the connecting gearing.

The methods (*a*) and (*b*) are, of course, only practicable when it is convenient to work the machines. The other method (*c*) necessitates particulars of the gearing only, and the draft can be ascertained at any time. It is the method most generally adopted, and is accurate. When it is inconvenient to obtain particulars of the connecting gear, an approximate result may be quickly arrived at by either of the former methods.

The following calculations illustrate the methods (*a*) and (*c*), the speeds representing the former, however, being those already ascertained by calculating from the connection with the driving

shaft, instead of by timing. Examples illustrating the application of the method (*b*) will follow.

Calculations relating to the drafts between the various contiguous parts comprised in the opener, as represented in Figs. 7, 8, 9, 10, *and* 11.

The draft between—

The supply and bottom lattice (Fig. 8)—

$$\left.\begin{array}{r}\text{By the calculated}\\ \text{surface speeds}\end{array}\right\} = \frac{73{\cdot}5''}{10{\cdot}94''} = 6{\cdot}718$$

$$\left.\begin{array}{r}\text{or, by the connect-}\\ \text{ing gear}\end{array}\right\} = \frac{85 \times 78 \times 7 \times 23 \times 17 \times 20 \times 20 \times 5\frac{1}{2}}{12 \times 1 \times 9 \times 55 \times 79 \times 48 \times 48 \times 5\frac{1}{2}} = 6{\cdot}714$$

The lower hopper lattice and the spiked lattice—

$$\text{By the calculated surface speeds} = \frac{422{\cdot}98}{73{\cdot}5} = 5{\cdot}76$$

$$\text{or, by the connecting gear} = \frac{48 \times 48 \times 5\frac{1}{2}}{20 \times 20 \times 5\frac{1}{2}} = 5{\cdot}76$$

The spiked lattice and the feed lattice to the porcupine cylinder (Figs. 8 and 9)—

$$\left.\begin{array}{r}\text{By the calculated}\\ \text{surface speeds}\end{array}\right\} = \frac{55{\cdot}01}{422{\cdot}98} = 0{\cdot}13$$

$$\left.\begin{array}{r}\text{By the connect-}\\ \text{ing gear}\end{array}\right\} = \frac{79 \times 55 \times 9 \times 1 \times 34 \times 27 \times 17 \times 3}{17 \times 23 \times 4 \times 62 \times 40 \times 33 \times 20 \times 5\frac{1}{2}} = 0{\cdot}13$$

The feed lattice and first presser roller to porcupine cylinder (Fig. 9)—

$$\text{By calculated surface speeds} = \frac{51{\cdot}337}{55{\cdot}01} = 0{\cdot}93$$

$$\text{By the connecting gear} = \frac{28 \times 3\frac{1}{2}''}{35 \times 3''} = 0{\cdot}93$$

The feed lattice and the first lower feed roller to the porcupine—

$$\text{By calculated surface speeds} = \frac{64{\cdot}7}{55{\cdot}01} = 1{\cdot}17$$

$$\text{By the connecting gear} = \frac{20 \times 3}{17 \times 3} = 1{\cdot}17$$

The first lower feed roller and the pedal roller—

$$\text{By the calculated surface speed} = \frac{72{\cdot}01}{64{\cdot}7} = 1{\cdot}11$$

$$\text{By the connecting gear direct} = \frac{33 \times 2\frac{3}{4}}{27 \times 3} = 1{\cdot}12$$

The pedal roller and the first bottom cage (Figs. 9 and 10)—

$$\text{By the calculated surface speeds} = \frac{102{\cdot}53}{72{\cdot}01} = 1{\cdot}423$$

By the connecting gear direct

$$= \frac{40 \times 62 \times 7 \times 20 \times 15 \times 13 \times 13 \times 24 \times 24 \times 40 \times 14 \times 44 \times 16}{34 \times 1 \times 5 \times 40 \times 30 \times 65 \times 38 \times 24 \times 30 \times 28 \times 44 \times 151 \times 2\frac{3}{4}}$$
$$= 1{\cdot}423$$

The first bottom cage and the first cage rollers (Fig. 10)—

$$\text{By the calculated surface speeds} = \frac{110{\cdot}5}{102{\cdot}48} = 1{\cdot}078$$

$$\text{By the connecting gear direct} = \frac{115 \times 44 \times 3}{44 \times 20 \times 16} = \frac{69}{64} = 1{\cdot}08$$

The first cage rollers, and feed rollers to beater—

$$\text{By the calculated surface speeds} = \frac{131{\cdot}6}{110{\cdot}5} = 1{\cdot}19$$

$$\text{By the connecting gear direct} = \frac{20 \times 2\frac{1}{2}}{14 \times 3} = 1{\cdot}19$$

The feed rollers to beater and the second bottom cage (Figs. 10 and 11)—

$$\left.\begin{array}{r}\text{By the calcu-}\\ \text{lated speeds}\end{array}\right\} = \frac{119{\cdot}78}{131{\cdot}6} = 0{\cdot}91$$

$$\left.\begin{array}{r}\text{By the connect-}\\ \text{ing gear direct}\end{array}\right\} = \frac{28 \times 30 \times 24 \times 38 \times 27 \times 25 \times 25 \times 16}{40 \times 24 \times 24 \times 71 \times 21 \times 23 \times 115 \times 2\frac{1}{2}} = 0{\cdot}91$$

Second bottom cage and the second cage rollers (Fig. 11)—

$$\text{By the calculated surface speeds} = \frac{148{\cdot}55}{145{\cdot}51} = 1{\cdot}02$$

$$\text{By the connecting gear direct} = \frac{115 \times 25 \times 3}{33 \times 16 \times 16} = 1{\cdot}02$$

Drafts (continued)—

First calender (top) and the second cage rollers—

$$\text{By the calculated surface speeds} = \frac{159{\cdot}15}{148{\cdot}55} = 1{\cdot}07$$

$$\text{By the connecting gear direct} = \frac{16 \times 21 \times 5''{\cdot}5}{25 \times 23 \times 3''} = 1{\cdot}07$$

Second and first calenders—

$$\text{By the calculated surface speeds} = \frac{166{\cdot}39}{159{\cdot}15} = 1{\cdot}045$$

$$\text{By the connecting gear direct} = \frac{23 \times 5''{\cdot}5}{22 \times 5''{\cdot}5} = 1{\cdot}045$$

Third and second calenders—

$$\text{By the calculated surface speeds} = \frac{174{\cdot}30}{166{\cdot}39} = 1{\cdot}047$$

$$\text{By the connecting gear direct} = \frac{22 \times 5''{\cdot}5}{21 \times 5''{\cdot}5} = 1{\cdot}047$$

Fourth and third calenders—

$$\text{By the calculated surface speeds} = \frac{172{\cdot}42}{174{\cdot}30} = 0{\cdot}99$$

$$\text{By the connecting gear direct} = \frac{21 \times 7''}{27 \times 5''{\cdot}5} = 0{\cdot}99$$

Lap rollers and the fourth calender—

$$\text{By the calculated surface speeds} = \frac{197{\cdot}42}{172{\cdot}55} = 1{\cdot}14$$

$$\text{By the connecting gear direct} = \frac{71 \times 21 \times 17 \times 8\frac{3}{4}}{13 \times 71 \times 30 \times 7} = 1{\cdot}14$$

The draft between the lap rollers and the feed rollers to the beater—

$$\left.\begin{array}{l}\text{By the calculated}\\ \text{surface speeds}\end{array}\right\} = \frac{197{\cdot}42}{131{\cdot}6} = 1{\cdot}5$$

$$\left.\begin{array}{l}\text{By the connecting}\\ \text{gearing direct}\end{array}\right\} = \frac{28 \times 30 \times 24 \times 38 \times 21 \times 17 \times 8\frac{3}{4}}{40 \times 24 \times 24 \times 13 \times 71 \times 30 \times 2\frac{1}{2}} = 1{\cdot}5$$

$$\left.\begin{array}{l}\text{By the intervening}\\ \text{drafts}^{1}\end{array}\right\} = \left\{\begin{array}{l}0{\cdot}91 \times 1{\cdot}02 \times 1{\cdot}07 \times 1{\cdot}045 \times 1{\cdot}047\\ \quad \times\ 0{\cdot}99 \times 1{\cdot}14 = 1{\cdot}225\end{array}\right.$$

[1] *This deficiency is due to the drafts between the various parts being incompletely expressed.*

The draft between the lap rollers and the pedal roller—

By the calculated surface speeds $\Big\} = \dfrac{197{\cdot}42}{72{\cdot}01} = 2{\cdot}74$

By the connecting gearing direct $\Big\} = \dfrac{40 \times 62 \times 7 \times 20 \times 15 \times 13 \times 21 \times 17 \times 8\frac{3}{4}}{34 \times 1 \times 5 \times 40 \times 30 \times 65 \times 71 \times 30 \times 2\frac{3}{4}} = 2{\cdot}72$

By the intervening drafts[1] $\Big\} = \Big\{ 1{\cdot}423 \times 1{\cdot}078 \times 1{\cdot}19 \times 0{\cdot}91 \times 1{\cdot}02 \times 1{\cdot}07 \times 1{\cdot}045 \times 1{\cdot}047 \times 0{\cdot}99 \times 1{\cdot}14 = 2{\cdot}30$

The knowledge of the amount of the draft between the various parts in a machine enables the relative weight of the cotton at each point of its progress to be ascertained, provided any loss between the points in question is allowed for.

Thus, if in the opener in question, the laps made weighed at the rate of 12 ozs. per yard, and the visible and invisible loss therein amounted to 3 per cent., and the draft between the various parts is as calculated below, the weight per yard of the cotton delivered by the spiked hopper lattice would be—

$$\left(\begin{matrix}\text{Weight of 1 yard}\\ \text{of opener lap}\end{matrix}\right\} + \left\{\begin{matrix}\text{per cent. of waste}\\ \text{extracted}\end{matrix}\right) \times \left\{\begin{matrix}\text{the draft between the}\\ \text{points in question}\end{matrix}\right.$$

$$\text{and } \therefore\ (12{\cdot}0 \text{ ozs.} \times \tfrac{100}{97}) \times \overset{(a)}{2{\cdot}72} \times \overset{(b)}{1{\cdot}12} \times \overset{(c)}{1{\cdot}17} \times \overset{(d)}{0{\cdot}13}$$

the last four items being the respective drafts from the lap rollers to the spiked lattice: (*a*) that between the lap and pedal rollers; (*b*) that between pedal and the lower feed rollers to the porcupine; (*c*) that between the feed and lattice rollers to the porcupine; (*d*) that between the feed and the spiked lattices.

The answer is 5·74 ozs.

The weight per yard of the cotton at the pedal roller would be—

$$12 \text{ ozs.} + 3 \text{ per cent. lost on the original weight} \times \text{draft}$$
$$\text{or, } 12 \text{ ozs.} \times \tfrac{100}{97} \times 2{\cdot}72$$

because the cotton composing the lap has been subjected to a loss of as 100 : 97, therefore that must be allowed for as well as

[1] *This deficiency is due to the drafts between the various parts being incompletely expressed.*

the length, contracted to the extent of 2·72 times the length delivered, thereby increasing the weight to that extent. Thus—

$$12 \times \tfrac{100}{97} \times 2{\cdot}73 = \left\{\begin{matrix}\text{the weight of the cotton}\\ \text{fed by the pedal roller } (x)\end{matrix}\right\} = 33{\cdot}77 \text{ ozs. per yd.}$$

The weight of the cotton at any other points may be similarly calculated, the weight being only approximate if the loss is unknown.

The following answers relate to the weight of the cotton at the various points, the loss between the pedal roller and first pair of cages being assumed as 2 per cent., and 1 per cent. between the first and second pairs of cages. The working of this question is given so that the student may accustom himself to the working of such exercises.

The weight of the cotton at—

Feed lattice to porcupine	44·1 ozs.
Pedal roller ,, ...	*Ans.* = 33·68 ,,

(Working.) Let x = weight of the cotton at the pedal roller—

$$\frac{(x - 3\,\%)}{\text{draft}} = \text{weight of cotton at delivery} \quad \therefore \frac{(x - 3\,\%)}{2{\cdot}72} = 12 \text{ ozs.}$$

$$\therefore \frac{x \times \frac{97}{100}}{2{\cdot}72} = 12 \text{ ozs.} \quad \therefore x = 12 \times \tfrac{100}{97} \times 2{\cdot}72 = 33{\cdot}68 \text{ ozs. } \textit{Ans.}$$

First pair of cages	*Ans.* = 23·4 ozs.
Feed rollers to beaters	*Ans.* = 18·2 ,,
Second pair of cages	*Ans.* = 19·8 ,,
Between calenders 3 and 4 . . .	*Ans.* = 13·68 ,,

It is customary to alter the draft by means of the wheels on the side shaft, also slight alterations by adjustments of the cone strap.

Exercises in Respect of Drafts in the Opener as per Details in Figs. 7, 8, 9, 10, and 11 inclusive, with Answers appended.

Find the drafts between the following parts by gear direct :—

(11) Spiked lattice and pedal roller. *Ans.* 0·171.

(12) Spiked lattice and feed roller to the beater. *Ans.* 0·31.

(13) Spiked lattice and lap rollers. *Ans.* 0·212.

(14) Pedal roller to cylinder and feed rollers to beater. *Ans.* 1·81.
(15) Pedal roller to cylinder and second bottom cage. *Ans.* 2·02.
(16) Pedal roller to cylinder and bottom calender. *Ans.* 2·38.
(17) Feed rollers to the beater and the first calender. *Ans.* 1·1.
(18) Feed rollers to the beater and the lap rollers. *Ans.* 1·5.
(19) The second bottom cage and the lap rollers. *Ans.* 1·35.
(20) First calender and the bottom calender. *Ans.* 1·08.

(21) Assuming that this opener produced laps which weighed at the rate of 13·5 ozs. per yard, what change in that weight would arise from each of the following alterations :—

(*a*) The 30 cross-shaft bevel changed to 27?
(*b*) The pinion on the bottom cone to 22, and that driving it on the side shaft to 38?
(*c*) The 5-inch pulley on the beater shaft to 6 inches?

Ans. 12·15 ozs.; 11·66 ozs.; 13·5 ozs.

(22) What changes would produce a lap weighing 10 ozs. per yard, assuming that with the gearing as in the figures the lap made weighs 12 ozs. per yard?

Scutchers.

The Particulars of Driving.—Speeds of the parts in the scutcher (Fig. 12).

In this figure B is driven by a belt from a 25-inch pulley on a counter shaft, and the latter is fitted with fast and loose pulleys, 15 inches in diameter, and these latter are driven by a belt from a 32-inch diameter drum on the line shaft, which makes 220 revolutions per minute.

The revolutions per minute of the various parts, together with the calculations, are as follows :—

$$\text{Beater shaft (B)} = \frac{220 \times 32 \times 25}{15 \times 10} = 1173\tfrac{1}{3}$$

$$\text{Fan} = \frac{220 \times 32 \times 25 \times 5}{15 \times 10 \times 7} = 838{\cdot}1$$

$$\text{Cross shaft} = \frac{220 \times 32 \times 25 \times 6}{15 \times 10 \times 12} = 586{\cdot}6$$

$$\left.\begin{array}{r}\text{Driver cone}\\ \text{drum (D)}\end{array}\right\} = \frac{220 \times 32 \times 25 \times 6 \times 6\frac{1}{2}}{15 \times 10 \times 12 \times 5\frac{1}{2}} = 693{\cdot}3$$

$$\left.\begin{array}{r}\text{Feed lattice}\\ \text{roller (F)}\end{array}\right\} = \frac{220 \times 32 \times 25 \times 6 \times 6{\cdot}5 \times 4{\cdot}5 \times 1 \times 39}{15 \times 10 \times 12 \times 5{\cdot}5 \times 4{\cdot}25 \times 88 \times 60} = 5{\cdot}422$$

$$\text{Surface rate} = \frac{5{\cdot}422 \times 3'' \times 22}{7} = 51''{\cdot}121$$

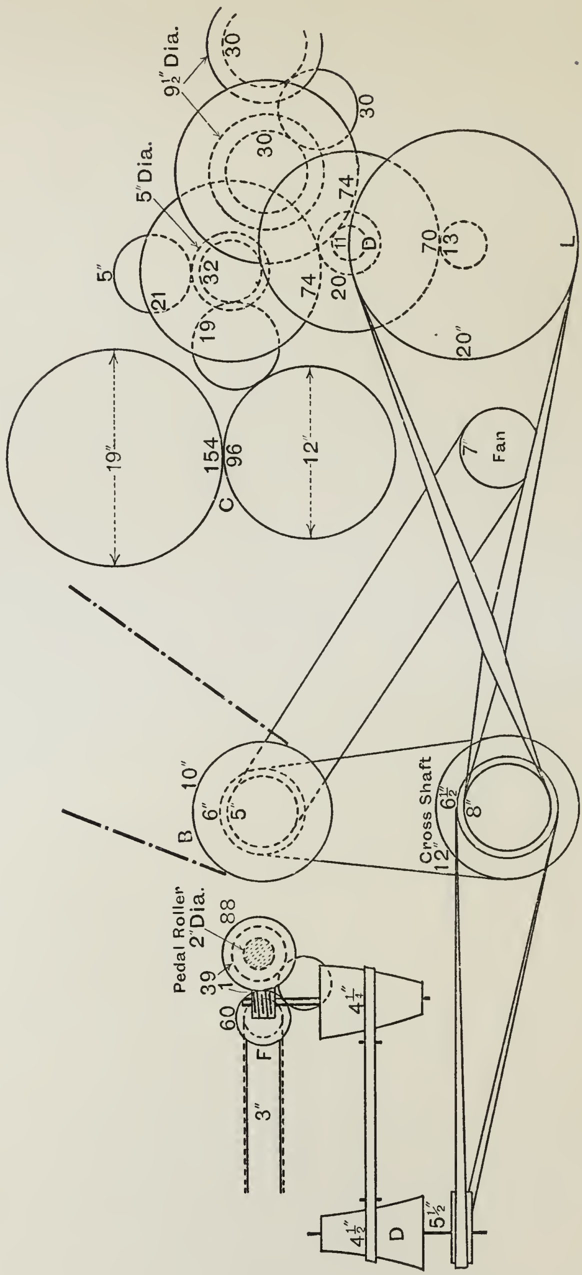

9½" Dia.
30
30
30
5" Dia.
74
5"
21
32
11
D'
70
13
L
74
20
19
20"
19"
154
96
C
12"
7"
Fan
10"
B
6"
5"
Cross Shaft
6½"
8"
12"
Pedal Roller
2" Dia.
88
39
1
60
F
4¼"
3"
4½"
D
5½"

Fig. 12.

$$\text{Pedal roller} = \frac{220 \times 32 \times 25 \times 6 \times 6{\cdot}5 \times 4{\cdot}5 \times 1}{15 \times 10 \times 12 \times 5{\cdot}5 \times 4{\cdot}25 \times 88} = 8{\cdot}342$$

$$\text{Surface rate} = \frac{8{\cdot}342 \times 2'' \times 22}{7} = 52''{\cdot}435$$

$$\left.\begin{array}{r}\text{Lap motion}\\ \text{shaft (L)}\end{array}\right\} = \frac{220 \times 32 \times 25 \times 6 \times 8}{15 \times 10 \times 12 \times 20} = 234{\cdot}6$$

$$\text{Bottom cage (C)} = \frac{220 \times 32 \times 25 \times 6 \times 8 \times 13 \times 20 \times 32}{15 \times 10 \times 12 \times 20 \times 71 \times 74 \times 96} = 3{\cdot}87$$

$$\text{Surface rate} = \frac{3{\cdot}87 \times 12'' \times 22}{7} = 145''{\cdot}988$$

$$\left.\begin{array}{r}\text{Top cage (C)}\\ \text{(19'')}\end{array}\right\} = \frac{220 \times 32 \times 25 \times 6 \times 8 \times 13 \times 20 \times 32}{15 \times 10 \times 12 \times 20 \times 71 \times 74 \times 154} = 2{\cdot}413$$

$$\text{Surface rate} = \frac{2{\cdot}413 \times 19'' \times 22}{7} = 144''{\cdot}09$$

$$\text{Top calender (21)} = \frac{220 \times 32 \times 25 \times 6 \times 8 \times 13 \times 20 \times 19}{15 \times 10 \times 12 \times 20 \times 71 \times 74 \times 21} = 10{\cdot}506$$

$$\text{Surface rate} = \frac{10{\cdot}506 \times 5'' \times 22}{7} = 165''{\cdot}094$$

Revolutions and surface speed per minute of—

$$\left.\begin{array}{r}\text{Bottom calender}\\ \text{(19–32)}\end{array}\right\} = \frac{220 \times 32 \times 25 \times 6 \times 8 \times 13 \times 20}{15 \times 10 \times 12 \times 20 \times 71 \times 74} = 11{\cdot}612 \text{ revs.}$$

$$\text{Surface rate} = \frac{11{\cdot}612 \times 5'' \times 22}{7} = 182{\cdot}474''$$

$$\left.\begin{array}{r}\text{Lap rollers } (9\tfrac{1}{2}''\\ \text{diameter)}\end{array}\right\} = \frac{220 \times 32 \times 25 \times 6 \times 8 \times 13 \times 11}{15 \times 10 \times 12 \times 20 \times 71 \times 74} = 6{\cdot}387 \text{ revs.}$$

$$\text{Surface rate} = \frac{6{\cdot}387 \times 9{\cdot}5'' \times 22}{7} = 190''{\cdot}696$$

Drafts between—

Pedal roller and feed lattice—

(*a*) By gear direct $= \dfrac{60 \times 2}{39 \times 3} = 1{\cdot}025$

(*b*) By the surface rates, already calculated $= \dfrac{52{\cdot}435}{51{\cdot}121} = 1{\cdot}025$

Bottom cage and pedal roller—

$$(a) = \frac{88 \times 4\frac{1}{4} \times 5\frac{1}{2} \times 8 \times 13 \times 20 \times 32 \times 12'' \text{ diameter}}{1 \times 4\frac{1}{2} \times 6\frac{1}{2} \times 20 \times 71 \times 74 \times 96 \times 2'' \text{ diameter}} = 2{\cdot}784$$

$$(b) = \frac{145{\cdot}988}{52{\cdot}435} = 2{\cdot}784$$

Top cage and bottom cage—

$$(a) = \frac{154 \times 12''}{96 \times 19''} = 1{\cdot}013$$

$$(b) = \frac{145{\cdot}988}{144{\cdot}09} = 1{\cdot}013$$

Bottom calender and bottom cage—

$$(a) = \frac{96 \times 5}{32 \times 12} = 1{\cdot}25$$

$$(b) = \frac{182{\cdot}474}{145{\cdot}988} = 1{\cdot}25$$

Lap rollers and bottom calender—

$$(a) \quad \frac{74 \times 11 \times 9\frac{1}{2}}{20 \times 74 \times 5} = 1{\cdot}045$$

$$(b) \quad \frac{190{\cdot}696}{182{\cdot}474} = 1{\cdot}045$$

Lap rollers and bottom cage—

$$(a) \quad \frac{96 \times 74 \times 11 \times 9\frac{1}{2}}{32 \times 20 \times 74 \times 12} = 1{\cdot}306$$

$$(b) \quad \frac{190{\cdot}696}{145{\cdot}988} = 1{\cdot}306$$

Lap rollers and pedal roller—

$$(a) \quad \frac{88 \times 4\frac{1}{4} \times 5\frac{1}{2} \times 8 \times 13 \times 11 \times 9\frac{1}{2}}{1 \times 4\frac{1}{2} \times 6\frac{1}{2} \times 20 \times 71 \times 71 \times 2} = 3{\cdot}63$$

$$(b) \quad \frac{190{\cdot}696}{52{\cdot}435} = 3{\cdot}63$$

Lap rollers and lattice roller—

$$(a) \quad \frac{60 \times 88 \times 4\frac{1}{4} \times 5\frac{1}{2} \times 8 \times 13 \times 11 \times 9\frac{1}{2}}{39 \times 1 \times 4\frac{1}{2} \times 6\frac{1}{2} \times 20 \times 71 \times 74 \times 3} = 3{\cdot}73$$

$$(b) \quad \frac{190{\cdot}696}{51{\cdot}121} = 3{\cdot}73$$

EXERCISES IN RESPECT OF THE PARTS IN FIG. 12.

EXERCISE 1.—What sizes of—

(*a*) Beater pulley would be required to give 1066 revolutions of that part per minute?

(*b*) Counter shaft drum (25 inches) would be required to give 1266 revolutions of beater shaft per minute?

(*c*) Pulley on the fan shaft would be necessary to give $1173\frac{1}{3}$ revolutions of fan per minute?

(*d*) Pulley on the beater shaft would be necessary to drive the fan 1675 revolutions per minute?

(*e*) To what extent would the weight produced by the machine be affected by the alterations (*a*) and (*b*) respectively?

(*f*) What changes respectively in the gearing would be expedient after making the alterations (*a*) and (*b*), if it was required that the weight produced in a given time remain as before the alteration?

EXERCISE 2.—What would the draft in the machine (Fig. 12) become, if the following alterations were made in the gearing:—

(*a*) The 8-inch pulley on the cross shaft changed to 9 inches and 7 inches successively?

(*b*) The $6\frac{1}{2}$-inch pulley on the cross shaft changed to 6 inches and 7 inches successively?

(*c*) The $6\frac{1}{2}$-inch and 8-inch pulleys, both on the cross shaft, are changed to 7 inches each?

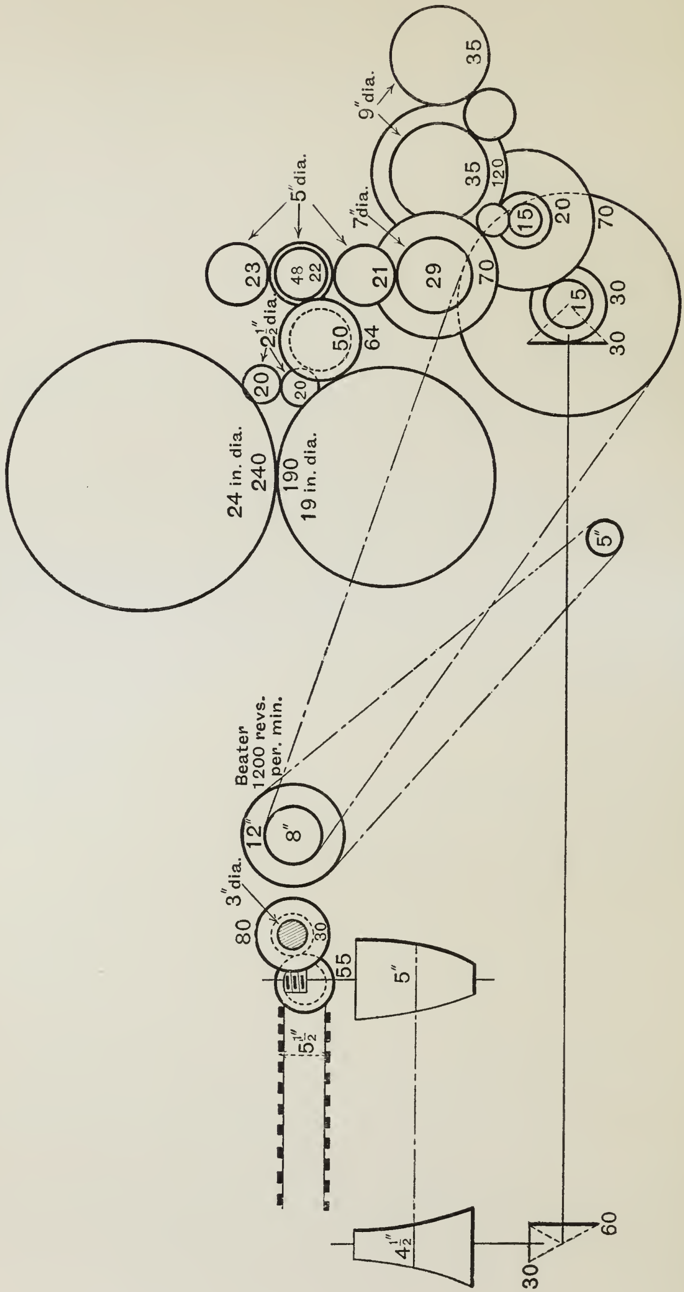
EXERCISE 3—

(*a*) Ascertain the weight, in pounds, per lap in each of the cases (*a*), (*b*), (*c*), Exercise 2, and also the number of laps made in 10 hours, assuming they measured 36·7 yards, and averaged 22 lbs. 15 ozs. each, with the gearing otherwise as per Fig. 12. Allow 10 per cent. for lost time.

(*b*) What change in the sizes of the $6\frac{1}{2}$-inch or 8-inch pulleys on the cross shaft would be necessary to produce a lap 12 ozs. per yard, if that made with the gearing, as per Fig. 12, weighed 10 ozs. per yard? Also, state the difference in the length and weight, in both instances, which would be caused by the change.

(*c*) What effect, upon the output of this machine, would result from an alteration in the position of the strap on the cones? Assuming the sum of the diameters of the cones at opposite points are $8\frac{3}{4}$ inches, and the strap is on a part of the driven cone 4 inches in diameter, what would be the weight per yard of the lap made, if that produced with the gearing, as per Fig. 12, was 10 ozs. per yard?

(*d*) If the lap made in a machine, geared as per Fig. 12, averaged 36·7 yards and weighed 22 lbs. 15 ozs., and the loss in the process was 2 per cent., and the number of laps used at the feed 4, what should be the weight per yard of each of the latter?



35
9" dia.
35
120
5" dia.
7" dia.
20
15
70
23
48
22
21
29
70
30
15
30
2½" dia.
50
64
20
20
24 in. dia.
240
190
19 in. dia.
5"
Beater
1200 revs.
per. min.
12"
8"
3" dia.
80
30
55
5"
5½"
4½"
30
60

FIG. 13.

Exercises in Calculating the Speeds and Drafts of the Various Parts in the Scutcher (Fig. 13).

Calculate the revolutions per minute of the following parts. The numerals signify the teeth contents in wheels and diameters of pulleys and other parts in inches.

Exercise 4—

(*a*) Fan (5 inches). *Ans.* 2880.
(*b*) Lap motion shaft (15–30). *Ans.* 400.
(*c*) Side shaft (30–60). *Ans.* 400.
(*d*) Driver cone ($4\frac{1}{2}$ inches). *Ans.* 800.
(*e*) Driven cone (5 inches). *Ans.* 720.
(*f*) Feed roller (30–80). *Ans.* 9.
(*g*) Feed lattice ($5\frac{1}{2}$ inches diameter). *Ans.* $4\frac{10}{11}$.
(*h*) Top cage (240). *Ans.* 4·842.
(*i*) Bottom cage (190). *Ans.* 6·116.
(*j*) Cage rollers (20). *Ans.* 45·4.
(*k*) First calender (23–5 inches). *Ans.* 23·15.
(*l*) Second calender (22–48–5 inches). *Ans.* 24·2.
(*m*) Third calender (21–5 inches). *Ans.* 25·35.
(*n*) Fourth calender (29–70–7 inches). *Ans.* 18·36.
(*o*) Lap rollers (35–120 and 35). *Ans.* 14·28.

Exercise 5.—Calculate the drafts between the following parts in the scutcher (Fig. 13):—

(*a*) Feed lattice and feed roller. *Ans.* 1·0.
(*b*) Feed roller and bottom cage. *Ans.* 4·3.
(*c*) Top and bottom cages. *Ans.* 1·0.
(*d*) Bottom cage and cage rollers. *Ans.* 0·976.
(*e*) Bottom cage and first calender. *Ans.* 1·04.
(*f*) Cage rollers and first calender. *Ans.* 1·067.
(*g*) First and second calenders. *Ans.* 1·045.
(*h*) Second and third calenders. *Ans.* 1·048.
(*i*) Third and fourth calenders. *Ans.* 0·987.
(*j*) First and fourth calenders. *Ans.* 1·11.
(*k*) Fourth calender and lap rollers. *Ans.* 1·0.
(*l*) First calender and lap rollers. *Ans.* 1·11.
(*m*) Feed lattice and lap rollers. *Ans.* 4·763.

Exercise 6—

(*a*) Give the drafts, from 4·763 to 3·2, which the following range in sizes of driver and driven draft change wheels would obtain, limiting the range in the driver 30–45 with 30 driven, and in the driven 20–30 with 30 driver.

(*b*) What single and pairs of draft change wheels, within the following sizes, driver 20–40, driven 20–50, will give drafts nearest 4·5, 4·1, 3·8, 3 5, 3·25, 3·0, and 2·85 respectively?

Answers to Exercise 6 (*a*)—

Driver . . .	31	32	33	34	35	36	37	38
Draft	4·61	4·56	4·35	4·2	4·08	3·97	3·86	3·76

Driver . . .	39	40	41	42	43	44	45
Draft	3·66	3·57	3·48	3·4	3·32	3·24	3·17

Driven . . .	30	29	28	27	26	25
Draft	4·76	4·6	4·45	4·28	4·13	3·97

Driven . . .	24	23	22	21	20
Draft	3·81	3·67	3·5	3·34	3·17

Answers to Exercise 6 (*b*)—

$4{\cdot}5 = \frac{\text{driver}}{\text{driven}}, \frac{40}{45}; \frac{21}{22}$ $\qquad 3{\cdot}25 = \frac{28}{41}$

$4{\cdot}1 = \frac{31}{36}$ $\qquad 3{\cdot}0 = \frac{22}{35}; \frac{29}{46}$

$3{\cdot}8 = \frac{24}{30}; \frac{27}{35}; \frac{32}{40}$ $\qquad 3{\cdot}5 = \frac{36}{48}; \frac{25}{34}$

$2{\cdot}85 = \frac{21}{35}$

The Hunting Cog Measuring or Length Motion used in Openers and Scutchers.—In Fig. 14, K and A represent the calenders and

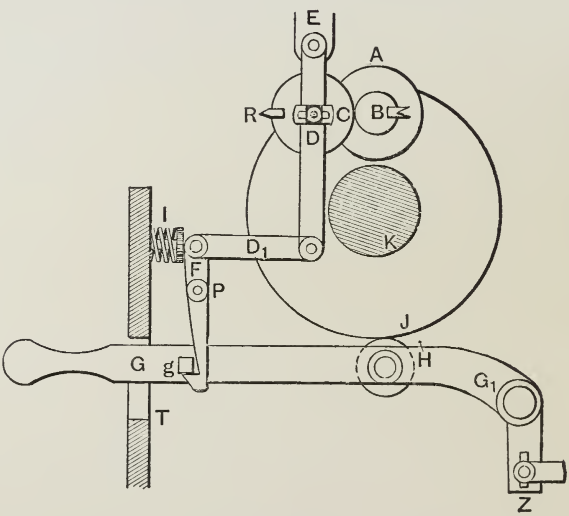


Fig. 14.

also the connecting wheels; H is the drop-shaft wheel; G the drop-shaft lever, G_1 being its pivot, *g* is a projection of G supported by the lower part of catch lever F, F is pivoted on P and

coupled to the lower part of lever D by D_1, D having its fulcrum at E. The spring I presses against D, forcing the wheel C, which is loose upon a stud attached to D, to gear with wheel B, the latter being fixed upon the shaft of the calender A. R and B are projections from the sides of the wheels C and B, which are in gear. When the projections meet the wheel C is forced out of gear with B, this action causes the levers D, D_1, and F to release *g*, and consequently G falls to T, thereby disengaging H from J, and, since the latter is driven by the former, J ceases to rotate. The fall of the lever G disengages the feed-motion clutch by rod connections with G shown at point Z. The lap continuing to rotate after the calenders have ceased delivering effects the severance and completion of the lap.

The length of the lap made is governed by the revolutions which the wheel B makes in causing its projection to have contact with R, on C.

The revolutions of the wheels B and C, per lap, *are the least whole numbers which express the relation of their tooth contents, their relative revolutions being inverse to those numbers.* Thus, if B is 21, and C ranged from 71 to 81 teeth respectively, the revolutions of these wheels, per lap, would be as given in the first part of the table on p. 50. If B had 72, and C ranged from 71 to 81 teeth, then their revolutions per lap would be as given in the second part of that table. If C had 80 and B 2 teeth, then their respective revolutions would be 1 and 40. Should C be any number which has no common divisor between itself and unity, then, if B contains less teeth than C, the revolutions of B per lap would be the same as the teeth contents of C.

Assuming the diameter of the calender 5 inches, then the length of the lap would be—

$$\frac{5'' \times 3{\cdot}1416 \times \text{revolutions of B per lap}}{36} = \text{yards}$$

$$\text{or, revolutions of B per lap} \times 0{\cdot}4363 \text{ yard}$$

Sizes of the wheels (in teeth).		Relative rate of their rotation.		Ratio of their teeth contents expressed in smallest whole numbers.		Revolutions of B per lap.	Length of the lap in yards as ascertained by calculation.
B.	C.	B.	C.	B.	C.		
21	71	71	21	21	71	71	30·98
21	72	72	21	7	24	24	10·47
21	73	73	21	21	73	73	31·85
21	74	74	21	21	74	74	32·29
21	75	75	21	7	25	25	10·91
21	76	76	21	21	76	76	33·16
21	77	77	21	3	11	11	4·8
21	78	78	21	7	26	26	11·34
21	79	79	21	21	79	79	39·47
21	80	80	21	21	80	80	39·90
21	81	81	21	7	27	27	11·77
72	71	71	72	72	71	71	30·98
72	72	72	72	1	1	1	$0{\cdot}436\dot{3}$
72	73	73	72	72	73	73	31·85
72	74	74	72	36	37	37	16·14
72	75	75	72	24	25	25	10·91
72	76	76	72	18	19	19	8·29
72	77	77	72	72	77	77	38·59
72	78	78	72	12	13	13	5·67
72	79	79	72	72	79	79	39·47
72	80	80	72	9	10	10	4·36
72	81	81	72	8	9	9	3·96

Example.—If C is 78 and B 41, and the diameter of the calender 5 inches, and the draft between this calender and the lap rollers 1·045, then the approximate length of the lap would be as follows:—

The ratio of the tooth contents of C and B cannot be expressed in less whole numbers, and hence B will make 78 revolutions per lap,

$$\therefore 78 \times 5 \times 3{\cdot}1416 \times 1{\cdot}045 = \text{length of lap in inches (approximate)}$$
$$= 1280{\cdot}36 \text{ inches} = 106{\cdot}7 \text{ feet}$$

It is found that, when the lap is very thick, the lap exceeds somewhat the calculated length ; but as this discrepancy is the same in respect of each lap of the same weight, it is generally neglected, and the calculated length taken as the actual.

The advantages of the hunting-cog motion is that it obtains the same length on each lap, and this cannot be claimed in respect of the other motions. This arises through the slow and irregular disengagement of the knocking-off catch in the latter.

Laps of a length representing any number of revolutions of the operating calender can be made by this motion.

EXERCISE 7—

(*a*) How many revolutions would B make, and what length of lap would result, if B and C were 41 and 81 respectively and calender 5 inches diameter? *Ans.* 106 feet.

(*b*) What length of lap would be made if B had 42 and C 81 teeth when the calender B is 5 inches in diameter? *Ans.* 35·3 feet.

(*c*) What sizes of B may be used for a lap of 36·2 yards if C had 83 teeth when the calender B is 5 inches in diameter? *Ans.* 1–82.

PLATT'S KNOCKING-OFF MOTION

In Fig. 15, K is the bottom calender and A is a single worm secured to it; B is a worm wheel driven by A, and C a pinion fixed upon the axis of B; C drives the "knocking-off" wheel D, the projection E on D pulls the catch F and the lever G, to which it is attached, in passing that point. This movement moves the lever G to the right on its pivot X until G ceases to support H. The latter is the drop-shaft lever and in consequence of the withdrawal of the support G, the drop-shaft wheel is disengaged from driving the calenders and other parts dependent upon them for their motion, and hence, delivery ceasing, the lap is completed.

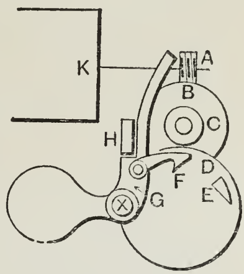


FIG. 15.

To start a new lap, G is raised at a point on the left to enable the clearance of the catch F from E, F is supported by a finger of the right hand, whilst the left lifts the drop lever H, when the weighted portion of G, to the left of X, causes it to move into a supporting position for H. This action engages the drop-shaft wheel, and sets the delivery and feed parts in action.

The length of the lap will vary according to the revolutions which the calender makes in turning the wheel D one revolution.

The gear may be as follows:—Bottom calender, 7 inches diameter; A, 1; B, 25; C, 18; D, 48.

The revolutions of A per one of D will therefore be—

$$\frac{48}{18} \times \frac{25}{1} = \frac{1200}{18}$$

$$\left.\begin{array}{c}\text{and the length of the}\\ \text{lap in yards}\end{array}\right\} = \frac{1200}{18} \times \frac{7'' \times 3{\cdot}1416}{36} = 40{\cdot}72\dot{4}$$

This type of length motion tends to the production of laps

slightly varying in length. This arises from the slow movement of part G during its withdrawal, and the tendency of its supporting surface to wear smooth and somewhat rounded; this, assisted by the vibration, causes the supporting part G to fall away at slightly varying intervals measured in revolutions of the calender.

Exercise 8.—Calculate the length of the laps—

(*a*) When C is 16, 17, 19, and 20 respectively. *Ans.* 45·75, 43·15, 38·6, 36·15 yards.

(*b*) When the following wheels are used together instead of those previously given: A, 1; B, 24; C, 17; D, 50. *Ans.* 43·15 yards.

(*c*) When B is altered to 24? *Ans.* 39·1 yards.

(*d*) When D is altered to 50? *Ans.* 42·5 yards.

Exercise 9—

If a lap 50 yards long is required, what single wheel would give the nearest result? *Ans.* Changing D to 59.

Exercise 10—

If a lap $48\frac{3}{4}$ yards was required, what size of C should be used? *Ans.* (5).

Exercise 11—

(*a*) What length of lap, in yards, would be made if the hunting-cog lap length motion wheel on the top calender contained 82 and the wheel on the knocking-off lever 83 teeth? *Ans.* 40·21.

(*b*) Find the time taken to make a lap 40·21 yards in length. *Ans.* 3·845 minutes.

(*c*) What would be the weight of one lap and also the production in lbs. per 10 hours, if 2 per cent. waste was extracted and the time lost in taking out the laps and other incidental stoppages equals 8 per cent. and the weight of the four laps comprising the feed each average 11·8 ozs. per yard. Assume the length of the lap 40·21 yards. *Ans.* 39 lbs.; 6006 lbs.

(*d*) What changes in the gear would be best to reduce the output to a normal amount, say to 3000 lbs. per 10 hours, without changing the count of the lap?

Ans. Reduce size of 8 inches, and increase size of 24 inches in corresponding proportions; or 8 inches to 6 inches, 24 inches to 30 inches.

Practical Notes.

Changes in the Weight and Count of the Laps made by Openers and Scutchers.—The position of the cone strap is automatically controlled by the feed regulator. To facilitate adjustments in the weight of the lap, as circumstances demand, an adjusting screw connection is provided. This latter, and changing the

draft gear, are the means of controlling the draft, and therefore of the weight and count of the lap made. The range of adjustment practicable, in respect of the draft by gearing, is unlimited ; but that by the adjustment of the cone strap is very limited, and should only be availed of for temporary adjustments.

The best position for the cone strap, when the feed is of the mean or normal weight, is at the centre of the cones. This secures the widest and most useful range of action of the cone strap, adaptable equally toward light and heavy variations in the feed. When, by temporary adjustments, so often necessitated by variations in the character of the cotton, and actions of the machine, common in ordinary working, the cone strap has been gradually moved and settled in a position otherwise than central, steps ought to be taken to alter the draft to an extent which will restore the cone strap to the centre position, or otherwise the efficacy of this part of the machine is interfered with.

The system of connecting the feed and delivery parts, in these machines, by belt, is being superseded by rope or tooth gear. The method shown in Fig. 12 is not always satisfactory. Variations in the slippage of the above-named straps affect the draft, and add to that arising from the cone strap. Positive driving reduces the possibilities of such defects without introducing any disadvantages.

Fluctuations in the draft are also often occasioned by variation in the slippage of the feed lattice ; too highly tensioned or slack lattices, lattice roller bearings out of alignment, and obstructions about these parts, binding of the lattice against the sides, these are amongst the chief causes of variations in the weight and count of the lap. The system of connecting the feed lattice rollers by tooth gear should receive consideration whenever the variations in the weight of the laps is unsatisfactory and cannot be eliminated.

Productions, Speeds, and their Controlling Factors.—In the spinning of coarse and medium counts of yarn from American and similar and lower types of cotton, exhaust openers are extensively used. In these machines the practice of dispensing the lap measuring and "knocking-off" motion is extensive. The advantages of such practice are, the elimination of the

thick and thin place, usually following the stoppage, and increased production; it is also a deterrent towards dilatoriness on the part of the attendant. Productions ranging as high as 40,000 lbs. per week of $55\frac{1}{2}$ hours are not uncommon under such conditions.

The rate of delivery ranges up to 30 feet per minute, and the rate of the feed about one-third of that amount. The weight of the cotton delivered ranges to 0·75 oz. per yard per inch of width, and that of the feed 2·5 ozs. per yard per inch of width.

The sizes of feed rollers are from $2\frac{1}{4}$ inches to 3 inches in diameter.

The highest surface rates of beating instruments range up to 10,000 feet per minute. Creighton porcupines up to 1000, small porcupine cylinders up to 1100, porcupines (discs) 900, large porcupines (36 inches and upwards) to 600, three-bladed beaters to 1250, two-bladed beaters up to 1500 revolutions per minute.

Fans range up to 2500 revolutions per minute.

The Controlling Factors in respect of the Parts and Speeds Named.—Small feed rollers are only adapted for light feeds at low rates and pressures. Feed rollers which have insufficient holding power depreciate the opening action by allowing "plucking." Overweighting in order to secure increased pressure—better holding power—has the same tendency. High rates of feed and beating, as well as heavy feeds, require larger feed rollers irrespective of the length of the staple. Too quick and overfeeding produces an excess of good cotton with the droppings, and interferes with the opening and cleaning actions. The sizes of feed rollers are from 2 inches to 3 inches diameter; $2\frac{1}{4}$ inches are only suitable when the feed is light, slow, and the pressure moderate. High speeds, accompanied by a heavy feed and pressure, necessitate rollers $2\frac{3}{4}$ inches to 3 inches diameter; $2\frac{1}{2}$ inches are only adapted for moderate conditions. Too close setting of these tends to weakening the fibres, whilst the opposite causes a stringy tendency in the appearance of the cotton. When large rollers are used $\frac{3}{16}$ inch would be satisfactory for the heaviest feed. With small feed rollers distances less than $\frac{1}{8}$ inch are doubtful.

High rates of beating cause good cotton to be forced through the beater bars, imparts a curly appearance, and also weakens the fibre.

Overscutching is distinguished by the development of the curling tendency.

There is a great variation in the rates at which fans are worked. This arises from constructional differences in respect of the exhaust trunks, passages, flues, etc., and dimensions of the fans. Deficient fan rates are signalized by the cotton being overscutched, desultory movement of the cotton from the beaters to the cages, presence of good cotton amongst the droppings. Too high rate of this part is distinguished by the rapid flight of the impurities along the passages, compact state of the cotton collected on the cages, absence of fine light impurities in the clearing casements and its presence in the cotton, low percentage of impurities extracted.

MISCELLANEOUS QUESTIONS APPERTAINING TO OPENING AND SCUTCHING.

(12) What number and weight of laps would be made in 10 hours under the following conditions?—4 laps comprise the feed in the scutcher, and these average 10 ozs. per yard each; the draft in the machine is 3, and the loss $1\frac{1}{2}$ per cent. The laps made are 42 yards long. The lap rollers are 9 inches in diameter, and make exactly 9 revolutions per minute, 30 seconds being lost at the completion of each lap. *Ans.* 108; 3720 lbs.

(13) How many scutchers, working under the conditions given in the last question, would be necessary to supply the laps for 108 cards, assuming each card produced 120 lbs. of 0·2 hank sliver and made 5 per cent. waste. *Ans.* 4.

(14) What should be the length in yards, the weight in pounds, and the number of laps made per 10 hours, if 4 laps, each weighing 10 ozs. per yard, form the feed in the scutcher geared as in Fig. 12, and the time lost altogether equals 10 per cent.? *Ans.* 10·456 ozs.; 2860 yds.; 1896 lbs.

EXERCISE 15 (Speeds).—Calculate the revolutions per minute of the principal parts in Fig. 13.

Answers—

Cross shaft, 400.
Fan shaft, 2880.
Side shaft, 400.
Driver cone, 800.
Driven cone, 720.
Feed roller, 9.
Lattice roller, 4·9.
Bottom cage, 6·11.
Top cage, 4·84.
Cage rollers, 45·4.
First calender, 23·15.
Second calender, 24·2.
Third calender, 25·35.
Fourth calender, 18·36.
Lap rollers, 14·28.

Exercise 16 (Drafts).—Calculate the drafts between the following parts in Fig. 13:—

Lattice and pedal rollers. (*Ans.* 1.)
Pedal roller and bottom cage. (*Ans.* 4·3.)
Bottom cage and cage rollers. (*Ans.* 0·976.)
" " top calender. (*Ans.* 1·04.)
First and second calender. (*Ans.* 1·045.)
Second and third calender. (*Ans.* 1·048.)
Third and fourth calender. (*Ans.* 0·987.)
Fourth calender and lap rollers. (*Ans.* 1·0.)

Production in pounds in 10 hours' uninterrupted working, assuming the lap weighs 5250 grains per yard. (*Ans.* 5050.)

Also, the draft between the feed lattice and lap rollers. (*Ans.* 4·76.)

Also, the weight, per yard, of the cotton fed, assuming the lap produced to weigh at the rate of 5250 grains per yard, allowing 2 per cent. for loss in waste. (*Ans.* 25,500 grains.)

Card Calculations.

Fig. 16 represents the gearing common in cards of the revolving flat type. In the different makes of these machines wheels and other parts of varying dimensions are adopted, to adapt them for the conditions under which they work. The subtended calculations relate to the speeds of all the parts which they contain; they are arranged in the following instances, as far as convenient, in progressive order. Slippage and thicknesses of belts and ropes have not been taken into consideration in these calculations, but it is advisable to do so in practice. In belt drives, under bad conditions, this is sometimes considerable, but under fair conditions should not amount to more than two or three per cent. at each point in transmission. The actual speeds will be, therefore, somewhat less than the calculated. The speeds given are those in common use in treating ordinary Egyptian and the better classes of American cotton.

The line shaft from which the strap driving the card, in the figure, is driven is assumed to make 220 revolutions per minute, and the drum upon it to be 12 inches in diameter.

The dimensions given refer to the diameters in inches in respect of pulleys, or teeth in cases of wheels.

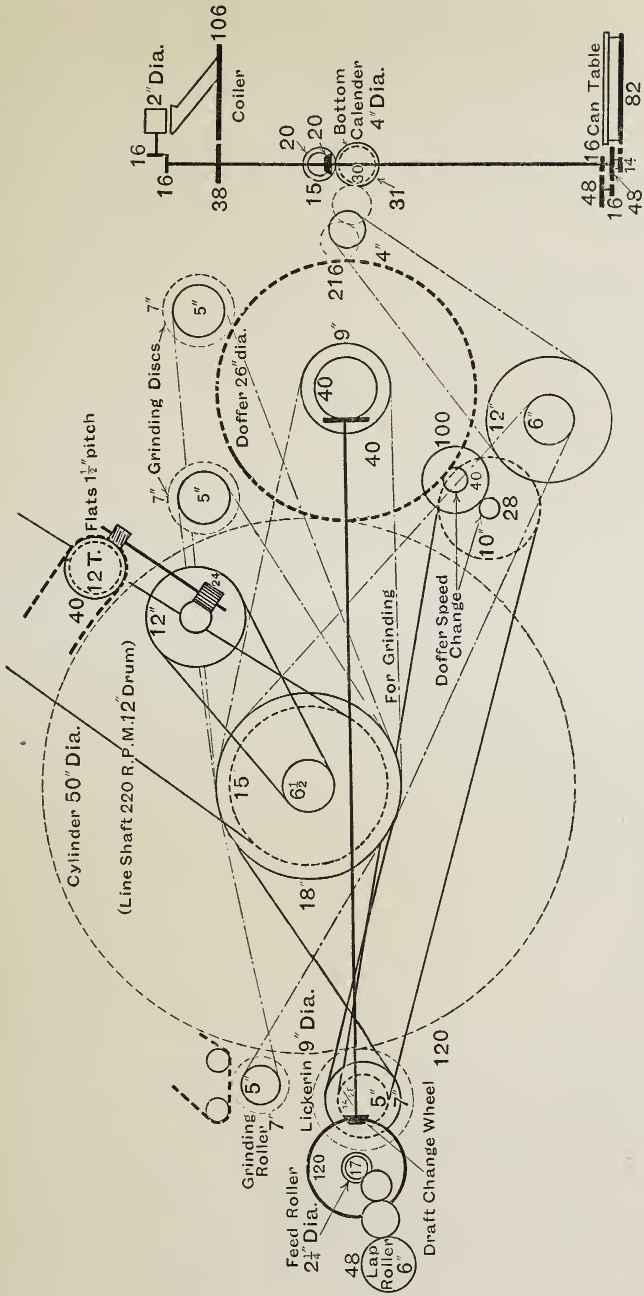

2″ Dia.
106
Coiler
16
16
38
20
20
15
Bottom Calender 4″ Dia.
30
31
16 Can Table
82
48
16
43
14
216
4″
7″
5″
Grinding Discs
Doffer 26″ dia.
9″
40
40
100
12″
6″
40
28
10″
Flats 1½″ pitch
12 T.
40
24
12″
(Line Shaft 220 R.P.M. 12″ Drum)
Cylinder 50″ Dia.
15″
6½
18″
For Grinding
Doffer Speed Change
Lickerin 9″ Dia.
120
5″
7″
Grinding Roller
Draft Change Wheel
120
17
Feed Roller 2¼″ Dia.
48
Lap Roller 6″

Fig. 16.

Details of calculation.	Revolutions per minute.	Surface speed per minute. In inches.	Surface speed per minute. In feet.
Lap roller—			
$\frac{220\times12\times18\times5\times28\times40\times40\times14\times17}{15\times7\times10\times100\times216\times40\times120\times48}=$	0·4848		
$\frac{0{\cdot}4848\times6\times22}{7}=$		9·1413	0·7617
The feed roller ($120\times17\times2\frac{1}{4}''$)—			
$\frac{220\times12\times18\times5\times28\times40\times40\times14}{15\times7\times10\times100\times216\times40\times120}=$	1·369		
$\frac{1{\cdot}369\times2\frac{1}{4}''\times22}{7}=$		9·68	0·806
The lickerin ($7''\times5''$)—			
$\frac{220\times12\times18}{15\times7}=$	452·57		
$\frac{452{\cdot}57\times9''\times22}{7}=$		12786·98	1065·58
The cylinder ($15''\times18''\times50''\times6\frac{1}{2}''$)—			
$\frac{220\times12}{15}=$	176		
$\frac{176\times50''\times22}{7}=$		27657	2304·75
The flats (40×12): here, in estimating the surface movement, it is assumed that the distance from centre to centre of the flats measures $1\frac{1}{2}$ inches, and are driven by a wheel containing 12 teeth, each of which engages a "flat." The worm, driving the worm wheel (40), has a double thread.			
$\frac{220\times12\times6\frac{1}{2}\times1\times2}{15\times12\times24\times40}=$	$\frac{143}{720}$		
$\frac{143\times12\times1\frac{1}{2}''}{720\times1\times1}=$		3·574	
Brushes: not shown. The driving gear for the brushes that clean the flats is not contained in the figure. The speed of that part varies; under exceptional circumstances it is worked as high as 300 revolutions per minute. The normal rate of the ordinary brush is about 40 revolutions per minute. A patent combination brush—which gives encouraging results—is worked as low as 5 revolutions per minute. The stripping brush used in cleaning the cylinder and doffer is driven, during that			

Details of calculation.	Revolutions per minute.	Surface speed per minute.	
		In inches.	In feet.
operation, from a groove in the loose pulley on the cylinder shaft, the diameter being 15 or 16 inches, whilst that on the brush varies from 5 to 10 inches, thus giving—			
From— $\frac{220 \times 12 \times 15}{15 \times 10} =$	264		
To— $\frac{220 \times 12 \times 15}{15 \times 5} =$	528		
The doffer (216 × 9″ × 40)— $\frac{220 \times 12 \times 18 \times 5 \times 28 \times 40}{15 \times 7 \times 10 \times 100 \times 216} =$	$11{\cdot}7\dot{3}$		
$\frac{176 \times 26 \times 22}{15 \qquad 7} =$		958·78	79·898
The bottom calender (30 × 31)— $\frac{220 \times 12 \times 18 \times 5 \times 28 \times 40}{15 \times 7 \times 10 \times 100 \times 30} =$	84·48		
[*Note.*—The doffer wheel is here a carrier]			
$\frac{84{\cdot}48 \times 4 \times 22}{7} =$		1062·03	88·5
The coiler delivery rollers (16)— $\frac{220 \times 12 \times 18 \times 5 \times 28 \times 40 \times 31 \times 20 \times 16}{15 \times 7 \times 10 \times 100 \times 30 \times 15 \times 20 \times 16} =$	174·57		
$\frac{174{\cdot}57 \times 2'' \times 22}{7} =$		1097·423	91·452
The coiler (106)— $\frac{220 \times 12 \times 18 \times 5 \times 28 \times 40 \times 31 \times 20 \times 38}{15 \times 7 \times 10 \times 100 \times 30 \times 15 \times 20 \times 106} =$	62·5		
The radius of the centre of the coiler tube at the point of exit is 3 inches— The distances traversed by this point =		1178	98·16
The can table wheel (82)— $\frac{220 \times 12 \times 18 \times 5 \times 28 \times 40 \times 31 \times 20 \times 16}{15 \times 7 \times 10 \times 100 \times 30 \times 15 \times 20 \times 48} \times \frac{16 \times 14}{48 \times 82} =$	3·31		

Details of calculation.	Revolutions per minute.	Surface speed per minute.	
		In inches.	In feet.
The number of coils laid per revolution of the can— $\frac{62.5}{3.31} =$	18·8		
Occasionally an alteration in the rate of the can is necessary through considerable change in thickness of the sliver. If the speed of the can is insufficient, the adjacent coils adhere instead of freely uncoiling. If the rate of the delivery is greater than the coiling rate, the sliver sticks to the sides of the can, and *vice versâ.*			
The doffer comb (4″)— $\frac{220 \times 12 \times 18 \times 12}{15 \times 6 \times 4} =$	1584		
It is now usual to furnish this part with a stepped pulley, also the driver of this is likewise stepped, so that the speed of the comb may be adapted to the rate of the doffer.			
The grinding disc, or roller, on the cylinder (5″ × 7″)— $\frac{220 \times 12 \times 18}{15 \times 5} =$	633·6		
$\frac{633.6 \times 7 \times 22}{7} =$		13,944	1162
The grinding disc, or roller, on the doffer: the doffer during grinding is driven from the 18-inch pulley on the cylinder during this action, the other gear being disconnected, the speed being— $\frac{220 \times 12 \times 18}{15 \times 9} =$	352		
$\frac{352 \times 26 \times 22}{7} =$		28,704	2392
The direction of the cylinder when grinding is opposite to the normal working direction. The doffer rotates in the same direction. This direction is opposite to that indicated by the bend of the card wire in both instances. The direction of the emery discs, or rollers, is opposing the movement of the parts to be ground.			

An increased or diminished rate of any of these parts may be obtained by altering the size of any of the wheels or pulleys,

not a carrier, in the intercepting train, the effect being in direct ratio in case of drivers, and inverse when driven wheels or pulleys.

The grinding of the flats is done at a similar speed to that of the cylinder, rollers being preferred to discs for this work.

To alter the Speeds of the Various Parts.—The speed of the lap rollers may be altered by changing the 48, driven wheel, on the lap-roller shaft, and also by the 17, driver wheel, on the feed-roller shaft.

The speeds of the lap and feed rollers may be altered by changing the 120, driven wheel, on the feed roller; the 14, driver wheel, on the side shaft; the 40, driven, on the side shaft; and the 40, driver, on the doffer shaft.

The speeds of the calender, coiler delivery rollers, coiler and can wheels may be changed by altering the doffer, 216, or the 30, calender shaft wheel.

The speeds of the doffer, feed and lap rollers, calender and coiler delivery rollers, and also the coiler and can wheels, may be changed by altering the 5-inch driver pulley on the lickerin shaft, the 10-inch barrow pulley (driven), the 28 driver wheel on the hub of the latter, the 100 and the 40 driven and driver respectively. All these are connections in the train driving the doffer from the lickerin.

The speeds of all the above parts may be changed by any alteration which increases the speed of the lickerin.

In the event of a change in the speed of the lickerin being required without change in the speeds of the parts driven from it, it would be necessary to alter the connecting train at some point between the lickerin and the doffer wheel, inversely to the former change.

Alteration in the movement of the flats may be effected by changing the $6\frac{1}{2}$-inch driver on the cylinder shaft, or the 12-inch driver pulley on the flat-motion shaft, or the double, for a treble, worm.

EXERCISES RE ALTERATION OF SPEEDS OF VARIOUS PARTS.

EXERCISE 1.—If the card cylinder makes 178 revolutions per minute when its fast and loose pulleys are 16 inches in diameter, at what rate would each of its parts work after changing the fast and loose pulleys to 18 inches diameter?

Answers—

Cylinder, 158·2.	Coiler, 56·6.
Lickerin, 402·2.	Can wheel, 2·94.
Doffer, 10·43.	Doffer comb, 1408.
Feed roller, 1·217.	Stripping brush, 235–470.
Lap roller, 0·431.	Grinding discs, 563.
Calender, 75·1.	Doffer (when grinding), 313.
Coiler delivery rollers, 155·18.	Flats (inches per minute), 1·589.

EXERCISE 2.—What alterations would be necessary to restore the speeds of all the parts implied in the last question, excepting the cylinder, to the original rates?

Answers—

18-inch pulley driving lickerin to 20·25 inches.
7-inch pulley driving barrow pulley to $6\frac{2}{9}$ inches.
18-inch pulley on cylinder driving the doffer comb to $20\frac{1}{4}$ inches, or 6-inch pulley to $5\frac{5}{9}$ inches.
$6\frac{1}{2}$-inch pulley on the cylinder driving the flats to 7·31 inches.
5-inch pulley on the grinding disc to $4\frac{4}{9}$ inches.

EXERCISE 3.—A card having a doffer 24·75 inches diameter, making 18 revolutions per minute, produces 550 lbs. of sliver per week. The driving pulleys are 16 inches diameter, and the cylinder makes 180 revolutions per minute. What size of pulleys would be needed to reduce the speed to 160 revolutions per minute? What effect would this change have upon the revolutions per minute of the doffer as well as upon the length and weight produced per week?

Ans. 18 inches; $\frac{1}{9}$ less length; $488\frac{8}{9}$ lbs. per week.

The Drafts between the Various Parts, how ascertained.—The draft may be ascertained by comparing the weight per unit of length of the cotton at the different points in the machine; also, by timing the speeds of the respective parts and ascertaining from this their ratio; and again, by calculating the mechanical value of the connecting train of gear and dimensions of surface.

It is preferable wherever possible to do this by the latter system, as it furnishes the most reliable data. The two other ways serve very well in ascertaining approximate results, and also in checking the calculated draft.

The results given below are arrived at, from, (*a*) the calculated speeds, as ascertained in the previous calculations; (*b*) the connectional gear and sizes of the surface.

The drafts between—

Lap and feed roller—

$$(a)\quad \frac{9{\cdot}68''}{9{\cdot}1413''} = 1{\cdot}06$$

$$(b)\quad \frac{48 \times 2\frac{1}{4}}{17 \times 6} = 1{\cdot}06$$

Feed roller and lickerin—

$$(a)\quad \frac{12786{\cdot}98}{9{\cdot}68} = 1321$$

$$(b)\quad \frac{120 \times 40 \times 216 \times 100 \times 10 \times 9}{14 \times 40 \times 40 \times 28 \times 5 \times 2\frac{1}{4}} = 1322$$

Lickerin and cylinder—

$$(a)\quad \frac{27657}{12787} = 2{\cdot}162$$

$$(b)\quad \frac{7 \times 50''}{18 \times 9''} = 2{\cdot}160$$

Flats and cylinder—

$$(a)\quad \frac{27657}{1{\cdot}787} = 15476$$

$$(b)\quad \frac{40 \times 24 \times 12 \times 50 \times 22''}{1 \times 1 \times 6\frac{1}{2} \times 1\frac{1}{2} \times 12 \times 7} = 15472$$

Cylinder and doffer—

$$(a)\quad \frac{958{\cdot}78}{26757} = 0{\cdot}0346$$

$$(b)\quad \frac{18 \times 5 \times 28 \times 40 \times 26''}{7 \times 10 \times 100 \times 216 \times 50''} = 0{\cdot}0346$$

Doffer and calender—

$$(a)\quad \frac{1062{\cdot}03}{958{\cdot}78} = 1{\cdot}107$$

$$(b)\quad \frac{216 \times 4''}{30 \times 26''} = 1{\cdot}107$$

Calenders and coiler delivery rollers—

$$(a) \qquad \frac{1097{\cdot}423}{1062{\cdot}03} = 1{\cdot}033$$

$$(b) \qquad \frac{31 \times 20 \times 16 \times 2''}{15 \times 20 \times 16 \times 4''} = 1{\cdot}03$$

The Drafts between the Various Parts, how altered.—It will be seen from the foregoing that the drafts between any of these parts may be altered by changing the size of any driver, or driven wheel, comprised in their connectional gear. Increasing the size of a driver increases the rate of the part nearest the feed, of the two parts concerned, and therefore reduces the draft, and *vice versâ*. Altering the driven wheels has the inverse of the aforementioned effects.

To ascertain the draft between other points than those given —which are those contained in the adjacent parts progressing through the machine—all that is necessary is to multiply together the intervening drafts between the parts involved. Thus—

The total draft, *i.e.* between the lap and coiler delivery rollers—

$$(a) \quad = 1{\cdot}04 \times 1332 \times 2{\cdot}16 \times 0{\cdot}0346 \times 1{\cdot}107 \times 1{\cdot}033 = 118{\cdot}4$$

By comparison of the surface speeds of these two parts—

$$(b) \quad = \frac{1097{\cdot}423}{9{\cdot}1413} = 120$$

By the connectional gear and sizes of parts—

$$(c) \quad = \frac{48 \times 120 \times 40 \times 216 \times 31 \times 20 \times 16 \times 2''}{17 \times 14 \times 40 \times 30 \times 15 \times 20 \times 16 \times 6''} = 120$$

The draft between the feed roller and the doffer—

$$(a) \quad = 1298 \times 2{\cdot}16 \times 0{\cdot}0346 = 97$$

$$(b) \quad = \frac{958{\cdot}78}{9{\cdot}68} = 99{\cdot}04$$

$$(c) \quad = \frac{120 \times 40 \times 26''}{14 \times 40 \times 2\frac{1}{4}} = 99{\cdot}04$$

Points to be considered when altering the Drafts.—The following should always be borne in mind when deciding the drafts between the various points:—

The draft between the lap and the feed rollers should not be more than sufficient to keep the lap straight. If this is exceeded irregularity in the cotton fed will result. Smooth lap rollers are liable to cause slipping of the lap, causing fluctuations, and a greater draft than that estimated. The corrugated and ribbed forms of lap roller eliminate this tendency.

The draft between the feed roller and lickerin varies considerably. It is customary to alter the speed of the former part whenever a change in the draft is necessitated. That of the latter part is rarely interfered with, being generally about one-half the rate of the cylinder. Altering the draft at this point, therefore, changes the rate at which the fibres are presented to the action of the lickerin, and therefore controls the duration of its combing action upon any given fibre.

The draft between the flats and the cylinder is regarded generally as fixed for different classes of cotton. Alterations in this are made by varying the speed of the flats. The rate of movement of the flats in the main governs the duration of the cylinder's action upon a given body of fibres, and also the amount of clean carding surfaces introduced, and hence it is proper to vary their speed according to the exigencies of carding. With neppy, dirty, and matted cottons a higher rate of this part is expedient. For low American, Indian, and like qualities of cotton, they are worked at about double the rate in vogue for the clean qualities of American and Egyptian.

The draft between the cylinder and doffer is also varied, probably more than is expedient. In this the speed of the doffer is often regarded as subordinate to the count of sliver. The propriety of this is discussed elsewhere. The draft between the doffer and the calender is only varied slightly. It should always be such that the sliver, or "web," does not sag to an extent which is detrimental. On the other hand, if the draft is too much, irregularity through overstretching will result. The draft between the calender and the coiler delivery rollers should be sufficient to maintain a slight tension at all times.

Conditions controlling the Output of a Card.—*General conditions.*—When circumstances demand an alteration in the quantity of the output, a knowledge of the limitations of each action are essential in deciding the best manner of procuring the same. This knowledge cannot be gained without intimate association with the work. Assistance of a general character may be afforded, and this is attempted in the following statements.

Greater the contrasting speeds of the carding parts, longer the fibres are desired to remain in the carding action; greater the length of the fibres treated, closer the carding surfaces; more numerous the fibres treated the greater the tendency to strain the fibres.

The greater the length of the fibres treated the longer the duration of the action of carding by reason of increased difficulty involved in their separation.

The more numerous the body of fibres present in the carding influences, beyond a certain limit: the greater the tendency of damage to them by rolling and excessive straining. This occurs whenever the quantity of fibres are in excess of the capacities of the available carding surfaces, and results in some portion of the weight of the flats being borne by the body of fibres instead of by the bend. This tendency increases as the crowding becomes more intense. This becomes apparent through the increased power required to drive the card. Such conditions are more likely to arise in treating long than with short, fibred cotton. Inconsistent increases in the power consumed by these machines, after alterations of this nature, may be regarded as signs of overcrowded carding surfaces and straining of the fibres.

Distinct conditions in respect of the actions of the carding parts.—The functions of the lickerin are to straighten the fibres composing the fringe of the lap, eliminate foreign matter, carry forward the treated fibres to the range of the cylinder's action.

The functions of the cylinder are to take the fibres from the lickerin, to carry them into the range of action of the card flats, whereupon the latter arrest those fibres otherwise than straight.

The action of the cylinder, about this latter portion of the machine, is directly upon those fibres held by the flats, and partially projecting in the carding action. The gradual straightening and withdrawal of these, introduces others more or less contiguous to the carding action. In this way the superabundance of fibres which the flats receive during the earlier period of their action are held in reserve, and gradually brought into the action. As the fibres are gradually separated and straightened, they are carried off by the cylinder.

The functions of the flats are to receive foreign bodies, fibres that are entangled as well as those that are not straight—not in line with the direction of the carding movement; to present such fibres to the range of action of the cylinder for a definite period. The facility of the flats to arrest and detain foreign bodies and to retain and present the fibres requiring carding, depends upon the efficacy of the points, composing those surfaces, and the quantity of these available.

Numerous sharp carding points accompanied with reasonable spacing are the active agents in arresting and presenting fibres for disentanglement and the retention of foreign matter and short fibres. A sufficient supply of clean wire points should be continually passing into action. Should this latter be insufficient the imperfectly carded cotton from the lickerin would be carried forward by the action of the cylinder, and in passing the crowded surface of points of the flats, would tend to embed those fibres already engaging the wire. Those fibres, brought forward, which cannot be accommodated by reason of the crowded character of the surfaces, are subjected to the pressure previously referred to, and are thus strained, ruptured, and nepped according to the degree of overcrowding.

To guard against the fibres becoming embedded care should be observed to ensure that the proper inclination of the bend in wire is preserved. This is often depressed through the stripping brush being used in an unclean condition, also by its being set too deep. The wire on all surfaces should have a fine keen point, and this should be maintained in as uniform a condition as possible.

The Rate of Movement of the Flats.—It would seem that if the

wire surfaces act as heretofore described, a period very much less than forty minutes would more than suffice for the selection of all the desirable fibres from those received by the flat whilst occupying the first position on the bend. Such may be the case, but since the flats when even in their last position arrest fibres—proved by passing a little coloured cotton in with the lap, this making its appearance on the next flat exposed—the best way in deciding the proper speed of flats is to recognize the strips from them as the index. The speed should be adjusted to give the lightest "strip" that will strip satisfactorily. To adjust the percentage of strip by manipulating the front stripping plate is wrong in principle. There is only one correct position for that part, and that is as near the flats and cylinder as practicable. Increasing its distance from the flats causes the detachment of portions of the entangled fibre and impurities selected in the carding action from the flats as they move out of action, and thus polluting the work otherwise accomplished.

In considering the rate of movement of the doffer, its functions as well as the length or the weight must be kept in mind.

The function of the doffer is to take the fibres from the cylinder. The more completely this is accomplished the better. Should the cylinder be only partially cleared of the fibres borne upon it, its influence in carding will be interfered with to that extent; because it reduces the extent of the surface of carding points at liberty to act upon those fibres presented by the lickerin and "flat" surfaces. The aim, therefore, in working the doffer should be to clear the cylinder as completely as possible, and to ensure this its surface rate should be as high as practicable. This rate cannot be specified only in general terms on account of the wide variations in the working conditions. Light slivers, poor staple, bad laps, poor selvedges, unsatisfactory doffing combs, badly constructed sliver casements, draughty rooms, all tend to restrict the speed at which the doffer can be run. Under favourable conditions 16 revolutions per minute can be attained.

The rate of the flats is as high as 3 per minute.

The rate of cylinders is 170–180 revolutions per minute for low American and like cottons.

The rate of cylinders is 160–175 revolutions per minute for Egyptian and American better qualities.

The rate of cylinders is 120–160 revolutions per minute for the longer stapled cotton than those enumerated above.

Changes in the Total Draft.—These are accomplished by altering any of the following four wheels: Bevel wheels on the doffer and side shaft and feed roller. Since the side shaft transmits the motion to the feed parts, a driver wheel will influence the rate of the feed in the direct ratio and the draft inversely, whilst a driven wheel will have the inverse effect. It is customary to alter the draft by means of the side shaft wheel, driving that on the feed roller, and hence it is called the draft change wheel. Whenever this is impracticable, on account of the limits in size of wheel applicable, it is customary to alter that on the feed roller to an extent providing a more convenient range of drafts with the wheels available. Occasionally the side shaft and doffer bevels are altered, but usually these are inconveniently fixed for this purpose.

Exercise 4.—What changes in each of the wheels forming the draft gear in Fig. 16 would give 160 of a draft, assuming the present draft 120?

Working and Answers—

$$\text{Bevel wheel on doffer shaft} = \frac{40 \times 120}{160} = 30$$

$$\text{Bevel on side shaft} = \frac{40 \times 160}{120} = 53\tfrac{1}{3}$$

$$\text{Side-shaft change wheel} = \frac{14 \times 120}{160} = 10\tfrac{1}{2} \left\{ \begin{array}{l} \text{(inconvenient;} \\ \text{too small)} \end{array} \right.$$

$$\text{Bevel wheel on the feed roller} = \frac{120 \times 160}{120} = 160\,[1]$$

Exercise 5.—What drafts would the following side-shaft change wheel give, respectively, assuming the card contains 120 of a draft when that wheel contains 18 teeth: 14, 15, 16, 17, 19, 20, 21, and 22?

Ans. 154·3, 144, 135, 127, 113·6, 108, 102·8, 98·3, respectively.

Exercise 6.—What sizes of side-shaft change wheels would be required to

[1] Usually changed to secure fresh range of drafts for the available side-shaft change wheel.

obtain the following drafts, assuming 14 gave a draft of 120: 112, 105, 99 93·5, 88·5?

Ans. 15, 16, 17, 18, 19.

Exercise 7.—What size of feed roller wheel would be necessary, assuming that card drafts ranging from 112 to 160 are required with the side-shaft change wheels 14 to 20 inclusive, and a 14 side-shaft change wheel driving a 120 on the feed roller give 120 of a draft?

Ans. 160.

What drafts would the various sizes of side-shaft change wheels give after making the alteration referred to in the last question?

Answers—

With the side-shaft change wheel	14	15	16	17	18	19	20
The draft would be . . .	160	149·3	140	131·8	124·4	118	112

Wrapping.

For measuring sliver and roves a special machine is used, called a wrapping machine. This is arranged to measure one yard per revolution. In using this instrument care must always be taken to secure the movement of the cotton in a straight line and also at a uniform tension, and at the same time precautions taken against slippage. Five or six yards will be sufficient length, and the sliver tested should be obtained from different parts of the can, and from several of the cards in the "preparation," in order to get precisely the conditions prevailing. The cotton, after being measured, should be compactly wound in the form of a ball to obtain accurate weighing.

Exercise 8.—What should be the weight in grains per yard of the sliver produced in cards containing the following total drafts respectively: 160, 149·3, 140, 131·8, 124·4, 118, 112, if the loss in the process in each case amounted to 5½ per cent., and the lap fed weighed 4375 grains per yard?

Ans. 25·8, 27·6, 29·5, 31·4, 33·2, 35, 36·8 respectively.

Exercise 9.—What should the sliver weigh, per 5 yards, respectively, with draft change wheels ranging from 15 to 22 inclusive, if 5 yards of the sliver weigh 134 grains with a 14 wheel?

Ans. 5 dwts. 23½ grs., 6 dwts. 9 grs., 6 dwts. 19 grs., 8 dwts. 4 grs., 8 dwts. 14 grs., 8 dwts. 23 grs., 9 dwts. 9 grs., 9 dwts. 18 grs.

Exercise 10.—What draft change wheel would give slivers weighing 9 dwts. 6 grs., 9 dwts. 20 grs., 10 dwts. 11 grs., 11 dwts. 2 grs., 11 dwts. 17 grs. respectively, per 6 yards, if with a 14 draft change 6 yards of the sliver weighs 203 grains?

Ans. 15, 16, 17, 18, 19.

The Names applied to Cotton in its Preparation.

The following are terms used to designate the cotton in its different stages of preparation :—

Yarn is the completely twisted thread of fibres.

Rove, or roving, the band of fibres twisted to bind them sufficiently to resist handling. It is thus described after treatment in the slubbing, intermediate, roving, and "Jack" machines.

Sliver, is the band of fibres devoid of twist; at least, it is regarded as such. This term is used when the cotton is in a round state, in the processes, between the carding and slubbing stages.

Lap, denotes that the fibres are in a sheet or ribbon, formed in a roll. This is the state at the opener, scutcher, card sliver lap, ribbon lap, and combing machines.

The System of "Counting" Cotton in its Various Stages of Preparation.—This is adopted to express the length per unit of weight in a concrete and simple form. The basis of the system, used, is that of numerating the units of length contained in one pound, avoirdupois; the unit of length, used, being one hank. A special length table is used for subdivision of the hank. It is as follows :—

54 inches ($1\frac{1}{2}$ yds.)	= 1 thread
80 threads (120 yds.)	= 1 lea
7 leas (840 yds.)	= 1 hank

The table of weights are—

24 grs.	= 1 dwt.
$18\frac{11}{48}$ dwts. ($437\frac{1}{2}$ grs.)	= 1 oz.
16 ozs. (7000 grs.)	= 1 lb.

Note.—The work is very much simplified by the adoption of grain weights and pounds. Much valuable time is lost in calculation when pennyweights and ounces are used.

Thus, the count signifies the number of hanks, in length, of the cotton which are required to weigh 1 lb., and therefore—

1 hank (840 yds.) of No. 1 $= 1$ lb. $= 7000$ grs.

1 lea ($\frac{1}{7}$ hank, or $\frac{840}{7}$ yds. $= 120$ yds.) of No. 1 $= \frac{1 \text{ lb.}}{7} = 1000$,,

$\frac{1}{2}$ lea ($\frac{1}{14}$ hank, or	$\frac{840}{14}$ yds.	=	60 yds.) of No. 1	=	$\frac{1 \text{ lb.}}{14}$ =	500 grs.
$\frac{1}{4}$,, ($\frac{1}{28}$,,	$\frac{840}{28}$,,	=	30 ,,) ,,	=	$\frac{1 \text{ lb.}}{28}$ =	250 ,,
$\frac{1}{10}$,, ($\frac{1}{70}$,,	$\frac{840}{70}$,,	=	12 ,,) ,,	=	$\frac{1 \text{ lb.}}{70}$ =	100 ,,
$\frac{1}{20}$,, ($\frac{1}{140}$,,	$\frac{840}{140}$,,	=	6 ,,) ,,	=	$\frac{1 \text{ lb.}}{140}$ =	50 ,,
$\frac{1}{120}$,, ($\frac{1}{840}$,,	$\frac{840}{840}$,,	=	1 ,,) ,,	=	$\frac{1 \text{ lb.}}{840}$ =	$\frac{25}{3}$,,

The above are the fractions of a hank usually measured when testing the count of the cotton in the various stages of its preparation.

In connection with the weight table a difficulty is experienced in remembering that $18\frac{11}{48}$ dwts. make 1 oz. To remember that 7000 grs. make 1 lb., and that 24 grs. make 1 dwt., also that 16 ozs. make 1 lb., reduces the difficulty experienced in recalling the number of pennyweights per ounce, because the penny-weights may then be reduced to grains and the grains to pounds. If a similar difficulty occurs with the number of grains in an ounce, by noting that 7000 grs. are contained in 1 lb. of 16 ozs., then $\frac{7000}{16} = 437\frac{1}{2}$, the grains in an ounce. In this way the difficulties so often experienced by beginners are overcome.

In order to ascertain the count when the weight of a given length is known, the procedure is to divide the weight into that of a similar length of count No. 1, each expression being reduced to common weight terms. Thus—

EXAMPLES—

For reasons, see page 73.

(*a*) Required the count when 1 lea = 50 grains = $\frac{1000}{50} = 20$

(*b*) ,, ,, ,, = 24 ,, = $\frac{1000}{1 \times 24} = 41 \cdot 7$

(*c*) ,, ,, ,, = 437·5 ,, = $\frac{1000}{1 \times 437 \cdot 5} = 2 \cdot 285...$

(*d*) ,, ,, ,, = 1 lb. = $\frac{1000}{1 \times 7000} = 0 \cdot 142...$

(*e*) ,, ,, 1 hank = 437·5 grains = $\frac{16}{1} = 16$

(*f*) Required the count when 1 hank = 24 grains $= \frac{7000}{24} = 292$

(*g*) " " " = 100 " $= \frac{7000}{100} = 70$

(*h*) " " 1 yard = 1 lb. $= \frac{1}{840 \times 1} = 0{\cdot}00119$

(*i*) " " " = 437·5 grains $= \frac{1 \times 16}{840 \times 1} = 0{\cdot}01905$

(*j*) " " " = 24 " $= \frac{1 \times 7000}{840 \times 24} = 0{\cdot}347$

(*k*) " " " = 1 " $= \frac{1}{840} \times \frac{7000}{1} = 8{\cdot}3$

Notes on the working of the preceding Examples.

(*a*) The weight of 1 lea of No. 1 = $\frac{1}{7}$ lb., or $\frac{7000}{7}$ grs.; thus, the numerator is 1000 and the denominator 50.

(*b*) The numerator is $\frac{1}{7}$ of the pennyweights in 1 lb., because it is the weight of 1 lea of No. 1 in pennyweights, the weight expression of the denominator used in this case.

$$\text{The pennyweights in } \tfrac{1}{7} \text{ of 1 lb.} = \frac{1 \times 7000}{7 \times 24}$$

$$\text{These converted to grains} = \tfrac{7000}{7} = 1000$$

$$\text{and 1 dwt. in grains} = 24$$

$$\therefore \tfrac{1000}{24} = 41{\cdot}7$$

(*c*) The numerator here is $\frac{1}{7}$ of 1 lb. in ounces = $\frac{16}{7}$, and the denominator 1;

$$\therefore \frac{16}{7 \times 1} = 2{\cdot}285\ldots; \text{ or, } \frac{7000}{7} \times \frac{1}{437{\cdot}5}$$

(*d*) The numerator in this case is again $\frac{1}{7}$ of 1 lb. and the denominator 1;

$$\therefore \tfrac{1}{7} \times \tfrac{1}{1} = \tfrac{1}{7} = 0{\cdot}142\ldots$$

(*e*) In this instance the numerator is 1 lb., or 16 ozs., and the denominator $\frac{1}{16}$ lb. or 1 oz. respectively, and hence the count $= \frac{1}{\frac{1}{16}}$ or $\frac{16}{1}$ respectively.

(*f*) The weight of pounds and ounces can always be more conveniently expressed in grains than in pennyweights, and hence the numerator is reduced to 7000 grs., and the denominator to 24 grs.;

$$\therefore \tfrac{7000}{24}$$

(*h*) One over 840 is the numerator, because it is the weight of yard of No. 1 expressed in pounds, and 1 the denominator.

Exercise 11.—What are the counts of—

(*a*) 1 lea = 4 dwts. 4 grs.?

(*b*) 60 yards = 2 dwts. 2 grs.?

(*c*) 95 yards = 50 grs.?
(*d*) $2\frac{1}{2}$ leas = 125 grs.?
(*e*) 4 leas = 1 dwt. 16 grs.?
(*f*) 1 yard = 1 dwt. 1 gr.?
(*g*) 5 yards = 7 dwts. 12 grs.?
(*h*) 1 yard = 12 dwts.?

What should be the weight in grains of—

(*i*) 1 yard of No. 1?
(*j*) 1 lea of 40^s, 36^s, 84^s, 79^s?
(*k*) 30 yards of 4^s?
(*l*) 60 yards of 10^s?
(*m*) 6 yards of $0{\cdot}2^s$?
(*n*) 15 yards of $0{\cdot}25^s$?
(*o*) 1 yard, 0·0340, in ounces?

Exercise 12.—What would be the count and weight in ounces per yard of the laps fed in cards containing each 120 of a draft if the amount lost in waste is 5 per cent., and the count and weight of the sliver are—

Respective count	0·267	0·241	0·192	0.16
Respective weight in grains per yard	31 2	34·6	43·3	52

Ans. Count =	0·002225	$0{\cdot}00208\dot{3}$	0·0016	$0{\cdot}0013\dot{3}$
Ounces per yard =	9	10	$12\frac{1}{2}$	15

Exercise 13.—What would be the count of the sliver and its weight in grains per yard if the draft in the card was 152 and the lap weighed 80 ozs. per yard, the loss in waste being 5 per cent.?

Ans. Count = 0·32
Weight = 27·35 grs.

Exercise 14.—What weight of sliver, in grains per yard respectively, would be necessary to enable a card to produce 800 lbs. of sliver per week of 55 working hours with a doffer $126\frac{3}{4}$ inches diameter when run at 16, 15, 14, 13, and 12 revolutions per minute respectively?

Ans. 45·5, 48·5, 52, 56, 61·7.

Exercise 15.—What would be the count and weight of the sliver, in grains per yard, in cards containing 120 of a draft, if the lap fed averaged 10, 11, 12, 13, and 14 ozs. per yard respectively, and the waste in carding was $5\frac{1}{2}$ per cent.?

Ans. 0·242	0·22	0·202	0·86 count.	
34·4	37·85	41·3	44·75 weight in grains per yard.	

Exercise 16.—What should be the weight of the sliver, in grains per yard, produced by a card containing 120 of a draft, if the lap weighs 10 ozs. per yard and the waste extracted is 5 per cent.?

Ans. 34·6 grs.

Exercise 17.—What should be the weight of the lap suitable for a card if the loss in waste is 5 per cent., the draft being 120 and the sliver is required to weigh 36 grs. per yard?

Ans. 4547 grs., or 10·38 ozs.

Exercise 18.—At what rate, in revolutions per minute, should the doffer in a card be worked in order to produce 400 lbs. of sliver of 34·6 grs. per yard in 54 hours' continuous working, if the doffer is 24·75 inches in diameter and the draft between this part and the coiler delivery roller is 1·10?

Ans. 10·5 revolutions.

The Length of Fillit required to Cloth the Cylindrical Surfaces.—In calculating the length of the fillit required, it is necessary to allow one coil extra in addition to that sufficient for holding. Thus, a cylinder 50 inches diameter, 38 inches wide, to be covered with fillit 2 inches in width, would require $\frac{38}{2}$ coils + 1, and the length for holding, say, about 6 feet—

$$\therefore \frac{50}{12} \times \frac{22}{7} \times \frac{40}{2} \text{ feet} + 6 \text{ feet} = 268 \text{ feet}$$

Doffers 24 inches diameter, 38 inches wide, clothed with $1\frac{1}{2}$ inches fillit, require about 4 feet for holding, and—

$$\frac{24}{12} \times \frac{22}{7} \times \frac{40}{2} \text{ feet} + 4 \text{ feet} = 130 \text{ feet}$$

The following is the procedure in forming the spirals, termed "half-lap" and tapered tail ends, respectively. The latter is commenced the width of one staple and increased gradually to the full width in a length equal to the first coil. The former is commenced one-third or one-half the width, and the spiral obtained in one and a half or two coils, the finishing ends terminating in the inverse manner.

Example of preparing "Half-lap."—Assuming the fillit contains six columns in the width, half the width will be convenient for the commencement; maintain this width for half a coil, and then proceed to add a column, on the right-hand side, at points equidistant in the next half coil. In doing this it is necessary to have the commencement of the last row of each column a distance from the first row of the next column of $\frac{4}{6}$ of $\frac{1}{3}$ of $\frac{1}{2}$ the circumference of the cylinder. Thus three columns would be added in the latter half of the first coil. Afterwards, commencement is on the right hand, the left half of the end of the first coil must be secured to the "jump-end" of the beginning

of the first coil, and the second coil is commenced with the right-hand half. The left-hand portion is prepared for the cut-away portion as follows: Proceed to widen the right half of the second coil by the addition of rows and columns on the left-hand side in the same manner and at the same rate as with the tapered portion of the first coil, but from the commencement of the second coil, thereby obtaining the full width at a point opposite the commencement of the taper in the first coil. This completes the preparation for cutting.

When the columns are odd in number, for instance, seven, commence with the width of three columns to extend over $\frac{3}{7}$ of the circumference, and then proceed to make the tapered portion over the remaining $\frac{4}{7}$ of the first coil, and put in the remaining three columns required to complete the spiral, in the first $\frac{3}{7}$ of the second coil. In the former instance the spiral extends over $1\frac{1}{2}$ coils at each end, and in the latter over $1\frac{3}{7}$.

The tapered tail end—completed in one coil—is defective in that the terminals cannot be sufficiently tensioned for satisfactory grinding and working. The tapering should always be on the inside and not on the outside, this being the most common method. Extending the taper in half-lap over the whole of the first coil, necessarily extends the taper over the second coil. This would largely reduce the number of wire points over these portions, making wide gaps of absent points. The finishing-off preparation is exactly the inverse of the commencement.

Remember that uniformity in the character of the point is dependent upon uniform resilence of the wire, and this support it obtains through the medium of the tension at the foundation.

The Sliver Lap Machine.

Fig. 17 represents some of the principal parts and the gearing in the sliver lap machine.

The object of this machine is to prepare a ribbon of fibres of uniform width, weight, and, as far as practicable, with the fibres laid parallel and distributed uniformly. This latter is only partially obtained, and hence the succeeding process.

The machine consists of parts having the following functions:—

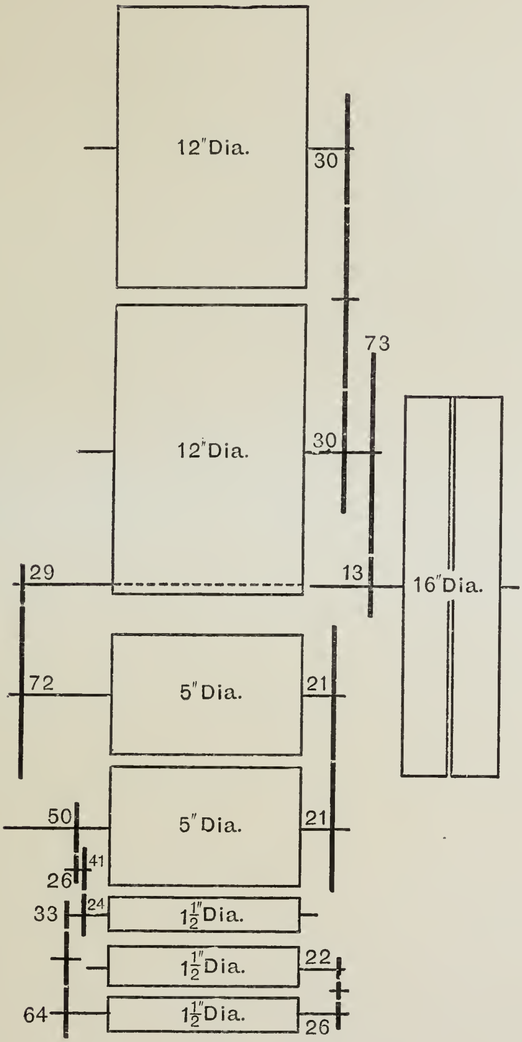


Fig. 17.

(*a*) The feed parts, not shown, for presenting a fixed number of the carded slivers in uniform tension, alignment, and placed as

close as practicable. Also means for the detection of missing slivers and stopping the machine.

(*b*) The rollers ($1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{2}$) for attenuating the above-named slivers to the most beneficial extent, this is generally up to about 2.

(*c*) The calenders ($5'' \times 5''$) for smoothing and pressing the attenuated ribbon of fibres.

(*d*) The lap rollers ($12'' \times 12''$) for winding the continuous ribbon of fibres tightly upon a wood roller.

Calculations relating to the Sliver Lap Machine (Fig. 17).—This machine is driven by a strap from a 9-inch drum on a line shaft making 220 revolutions per minute.

The calculated revolutions per minute of the various parts are as follows :—

Machine shaft (16″–13–29) $= 123{\cdot}75$, or, $\dfrac{220 \times 9}{16}$

First drawing roller (64–26–1½″) $= 84{\cdot}2$, or, $\dfrac{220 \times 9 \times 29 \times 21 \times 50 \times 41 \times 33}{16 \times 72 \times 21 \times 26 \times 24 \times 64}$

Second drawing roller (22–1½″) $= 99{\cdot}5$, or, $\dfrac{220 \times 9 \times 21 \times 50 \times 41 \times 33 \times 26}{16 \times 21 \times 26 \times 24 \times 64 \times 22}$

or, $\dfrac{84{\cdot}2 \times 26}{22}$

Third drawing roller (24–33–1½″) $= 163{\cdot}3$, or, $\dfrac{220 \times 9 \times 29 \times 21 \times 50 \times 41}{16 \times 72 \times 21 \times 26 \times 24}$

First and second calenders (50–5″), (72–5″) $= 49{\cdot}8$, or, $\dfrac{220 \times 9 \times 29}{16 \times 72}$

and $\dfrac{220 \times 9 \times 29 \times 21}{16 \times 72 \times 21}$

Lap rollers (12″–73–30) $= 22{\cdot}04$, or, $\dfrac{220 \times 9 \times 13}{16 \times 73}$

and $\dfrac{220 \times 9 \times 13 \times 30}{16 \times 73 \times 30}$

Drafts—

Between second and first rollers $= 1{\cdot}18$, or, $\dfrac{26 \times 1\frac{1}{2}''}{22 \times 1\frac{1}{2}''}$

Between third and second rollers $= 1{\cdot}64$, or, $\dfrac{22 \times 64 \times 1\frac{1}{2}''}{26 \times 33 \times 1\frac{1}{2}''}$

Between third and first rollers $\Big\} = 1{\cdot}94$, or, $\dfrac{64 \times 1\frac{1}{2}''}{33 \times 1\frac{1}{2}''}$

Between calender and third roller $\Big\} = 1{\cdot}014$, or, $\dfrac{24 \times 26 \times 5''}{41 \times 50 \times 1\frac{1}{2}''}$

Between calender and first roller $\Big\} = 1{\cdot}97$, or, $\dfrac{64 \times 24 \times 26 \times 5''}{33 \times 41 \times 50 \times 1\frac{1}{2}''}$

Between lap roller and calender $\Big\} = 1{\cdot}12$, or, $\dfrac{72 \times 13 \times 12''}{29 \times 73 \times 5''}$

Between lap roller and first roller $\Big\} = 2{\cdot}08$, or, $\dfrac{64 \times 24 \times 26 \times 21 \times 72 \times 13 \times 12''}{33 \times 41 \times 50 \times 21 \times 29 \times 73 \times 1\frac{1}{2}''}$

Production.—What should the lap weigh in grains per yard if the number of slivers fed are 14, and each weigh 30 grains per yard?

Ans. 202, or, $\dfrac{14 \times 30}{2{\cdot}08}$.

What should be the weight of lap produced in pounds per week of 55 hours, no allowances?

Ans. 2182, or, $\dfrac{22{\cdot}04 \times 55 \times 60 \times 12 \times 22 \times 202}{36 \times 7 \times 7000}$.

What length in hanks per week should be delivered under the conditions given?

Ans. 90, or, $\dfrac{22{\cdot}04 \times 55 \times 60 \times 12 \times 22}{840 \times 36 \times 7}$.

To alter the Production.—To alter the length delivered: Change the speed of the whole by altering the machine pulleys.

To alter the weight delivered: This may be done by allowing the length to remain unaltered or otherwise; in the latter case the weight-unit of the lap need not be altered, but in the former it would be necessary. The weight-unit of the lap and of the production may be altered by changing the draft or the weight of the feed. Draft affects the weight in the inverse proportion, whilst change in the weight of the feed would act in the direct proportion.

Changes in the draft of this machine are not frequent. When necessary they are confined to the alteration in the draft between the first and third drawing rollers.

Exercises in Changing the Sliver Lap Machine.

Exercise 1.—With the speeds as in the figure (17), what effect would changing the weight of the sliver, from 30 to 36 grains per yard, have upon the laps produced: (*a*) The weight per yard? (*b*) The weight produced per unit of time? (*c*) The length produced in hanks? *Ans.* 252 grs.; 2620 lbs.; 90 hanks.

Exercise 2.—What changes would be necessary if the sliver used was altered from 30 grains to 36 grains per yard, in order that the weight and length units, delivered, be unaffected?

Ans. Alter the draft change wheel to increase the draft : : 30 : 36.

Exercise 3.—What changes would secure the same weight per unit of time, and at the same time alter the weight of the lap $\frac{1}{16}$? *Ans.* Altering the draft $\frac{1}{16}$.

Exercise 4.—What would be the weight per yard, and of laps per 10 hours, if each lap measured 280 yards and one minute is lost at the completion of each? The lap rollers being of the size given in the figure, and make 20 revolutions per minute; each of the fourteen slivers fed weigh 28 grains per yard, and the draft in the machine is 2·08.

The Ribbon Lap Machine.

Fig. 18 represents some of the principal parts and the gearing in a ribbon lap machine.

The object of the machine is: to prepare from the sliver laps one which has the fibres arranged in the most suitable manner for combing; to make the ribbon of fibres uniform in thickness, width, and weight throughout, and with all the fibres parallel.

This machine consists of parts having the following functions:

(*a*) The feed parts: Lap rollers 3 ins. diameter, and the detector of missing and light laps; the latter is not shown.

(*b*) The rollers ($1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{2}$) for attenuating the ribbon of fibres to the extent necessary, to lay the fibres parallel, and to make the ribbon the desired weight.

(*c*) The curved folding plate C guides the ribbon, passing from the rollers, on to the folding table D, placing it upon the latter at right angles to the rollers. In the figure only one head is shown. The machine is usually made with six heads, to treat six sliver laps, and hence the rollers are constructed to deal with that number. There are, therefore, six curved folding plates, and the folding table is continued to the left accordingly.

(*d*) The carrier and compressing rollers, 3 ins. diameter, are placed at intervals along the folding plate to move forward the folded ribbons.

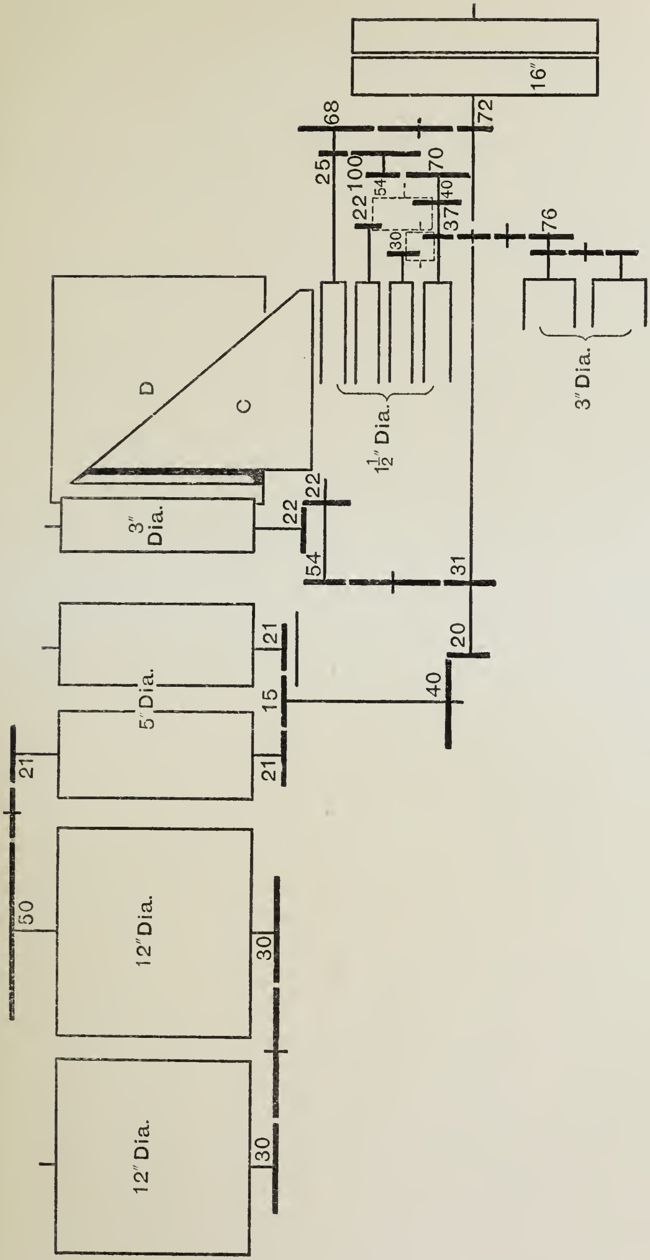

16"
68
72
25
100
70
54
40
22
37
30
76
D
C
1½" Dia.
3" Dia.
3" Dia.
22
22
54
31
21
20
5" Dia.
15
40
21
21
50
12" Dia.
30
12" Dia.
30

Fig. 18.

(*e*) The calender rollers (5″ × 5″) for smoothing and pressing the ribbons and completely uniting them.

(*f*) The lap rollers (12″ × 12″) for winding the continuous ribbon of fibres, or lap, tightly upon a wood roller.

The machine is driven by a strap from a 9-inch drum on the line shaft which makes 220 revolutions per minute and drives the 16-inch pulleys on the machine shaft.

The revolutions per minute of its various parts are as follows:—

Feed lap rollers (3″) = 13·5, or, $\dfrac{220 \times 9 \times 72 \times 25 \times 54 \times 30}{16 \times 68 \times 100 \times 70 \times 56}$

The first draw roller (37–40–70) = 25·3, or, $\dfrac{220 \times 9 \times 72 \times 25 \times 54}{16 \times 68 \times 100 \times 70}$

The fourth draw roller (68–25–1½″) = 131, or, $\dfrac{220 \times 9 \times 72}{16 \times 68}$

The carrier and compressing roller (22–3″) = 71, or, $\dfrac{220 \times 9 \times 31 \times 22}{16 \times 54 \times 22}$

The calenders (21–5″) = 44·25, or, $\dfrac{220 \times 9 \times 20 \times 15}{16 \times 40 \times 21}$

The lap rollers (12″–12″) = 18·55, or, $\dfrac{220 \times 9 \times 20 \times 15 \times 21}{16 \times 40 \times 21 \times 50}$

Drafts—

Between first roller and the feed lap roller = 1·02, or, $\dfrac{76 \times 1\frac{1}{2}}{37 \times 3}$

Between second roller and the first roller = 1·23, or, $\dfrac{37 \times 1\frac{1}{2}}{30 \times 1\frac{1}{2}}$

Between third roller and the second roller = 1·48, or, $\dfrac{30 \times 40 \times 1\frac{1}{2}}{37 \times 22 \times 1\frac{1}{2}}$

Between third roller and the first roller = 1·82, or, $\dfrac{40 \times 1\frac{1}{2}}{22 \times 1\frac{1}{2}}$

Between fourth roller and the third roller = 2·86, or, $\dfrac{22 \times 70 \times 100 \times 1\frac{1}{2}}{40 \times 54 \times 25 \times 1\frac{1}{2}}$

Between fourth roller and the first roller = 5·18, or, $\dfrac{70 \times 100 \times 1\frac{1}{2}}{54 \times 25 \times 1\frac{1}{2}}$

Between carrier and the fourth roller = 1·18, or, $\dfrac{68 \times 31 \times 22 \times 3}{72 \times 54 \times 22 \times 1\frac{1}{2}}$

Between calender and carrier roller = 1·03, or, $\dfrac{22 \times 54 \times 20 \times 15 \times 5}{22 \times 31 \times 40 \times 21 \times 3}$

$$\left.\begin{array}{l}\text{Between lap rollers and}\\ \quad\text{the calenders}\end{array}\right\} = 1{\cdot}01, \text{ or, } \frac{21 \times 12}{50 \times 5}$$

Between delivery lap rollers and the feed lap rollers = 6·05,

$$\text{or, } \frac{76 \times 70 \times 100 \times 68 \times 20 \times 15 \times 21 \times 12}{37 \times 54 \times 25 \times 72 \times 40 \times 21 \times 50 \times 3}$$

Production.—The weight, per unit of length of the lap made, is controlled by the weight of the laps fed, and by the total draft. Any alteration in the latter items affect the former in the direct and inverse proportions respectively, namely—

The heavier the feed, the heavier the lap, and *vice versâ.*

The greater the draft, the lighter the lap, and *vice versâ.*

The length delivered is only affected by the alteration of speed of the machine shaft.

It is customary to regulate the weight of the lap by altering the draft; but sometimes by altering the weight of the lap fed.

The draft can be altered to a very considerable extent without influencing the quality of the work.

The customary changes are made through: The pinion (54) or the back-roller wheel (70) for the draft; the machine pulleys (16 inches) for speed.

The restrictions in altering the draft and weight of the feed arise from the gross weight of the laps that are required for the combing machines.

Example 1.—If this machine has six heads, and the laps fed each weigh at the rate of 202 grains per yard; what weight of laps in pounds would be produced in 10 hours' uninterrupted working, and what would be the weight of these in grains per yard?

$$\textit{Ans. } \frac{202 \times 6}{6{\cdot}05} = 200 \text{ grains per yard}$$

$$18{\cdot}55 \times \frac{12}{36} \times \frac{22}{7} \times \frac{10 \times 60 \times 200}{7000} = 333 \text{ lbs.}$$

Example 2.—What would be the weight of the laps per yard if the draft-change pinion 54 was changed to 36? How would this change influence the weight and length produced in ten hours?

Ans. The draft would be altered in the inverse proportion to the change wheels, and hence—

$$\frac{6{\cdot}05 \times 54}{36} = 9{\cdot}07$$

and the weight per yard of the lap produced would become lighter in direct proportion to the change in this wheel, and therefore—

$$\frac{200 \times 36}{54} = 133 \text{ grains per yard}$$

And the weight produced in 10 hours would be affected in the same terms, 54 : 36, the length remaining unaffected.

Exercises.

1. The feed consists of six heads, and the weight per yard of the laps is 240 grains, the draft required being 5. What weight of lap, per yard and per 10 hours, should be produced, allowing $2\frac{1}{2}$ per cent. for stoppages? Also, what draft pinion wheel would be necessary to adapt the machine, other particulars being as per Fig. 18?

2. If the machine was producing laps weighing 240 grains per yard, geared as in Fig. 18, what would be the average weight per yard of the laps fed?

3. Upon testing the weight of the laps produced, they are found 224 grains per yard instead of 240 grains: what sizes of draft pinion or back-roller wheel would restore the laps produced to their proper weight? Also, give the proportional alteration that this change would make in the weight of laps produced per unit of time.

4. If the draft pinion 54 was changed to 60, what effect would it have upon the drafts between: (*a*) the first and second; (*b*) the second and third; (*c*) the third and fourth rollers respectively?

5. If the weight per yard of the laps produced became 240 grains instead of 200, what would you suspect, and what would you do?

Combing Machines.

Fig. 19 represents the gearing in the Nasmith combing machine.

The object of this machine is to comb the fibres and reject those that are defective and below a specified length.

The cotton for treatment in this machine is prepared from the card sliver, by the sliver and ribbon lap machines, an alternative to these processes being one head of drawing followed by the Derby Doubler. The former is the modern system, and has many advantages over the latter, the chief of these advantages being a reduction in the good fibres wasted.

The names of the parts in the figure are as follows:—

E, the lap rollers.

F, the pawl actuating the lap roller gear.

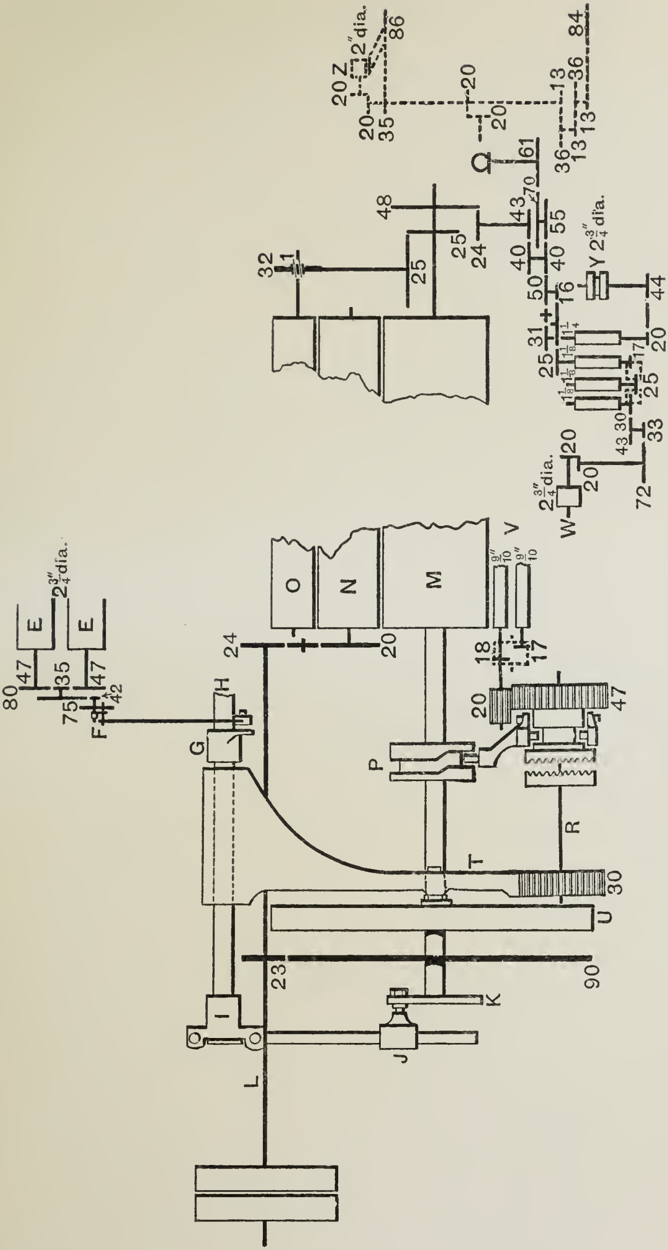


FIG. 19.

G, a crank on the oscillating shaft H.

HI, the oscillating shaft for operating the feed and the advancing and receding movements of the nippers.

J, a lever coupled to the shaft HI at I.

K, a crank; its stud and slide operate the lever J.

L, the machine driving shaft.

U, a cam on the comb cylinder shaft.

T, a quadrant rack lever centred on HI, and actuated by a stud and bowl, the latter projecting into the cam U.

R and 30 is the quadrant rack pinion and spindle.

47 is an escapement clutch, the left toothed portion being secured to the spindle R, the right portion being loose upon R, and engaged and disengaged with the left portion to obtain movement of the wheel containing 47 teeth.

P, a cam for controlling the clutch Q.

V are the detaching rollers connected by a train of wheels, 47, 20, 18, 17, with the clutch.

M, the comb cylinder.

N, the brush cylinder.

O, the card cylinder.

W, the head calender; there is one for each head.

30, 25, 17, 20, are the "draw-box." The draw-rollers are four in number, to attenuate the combed slivers.

Y, the draw-box calender.

Z, the coiler delivery rollers, and the coiler and can wheels are shown beneath.

The speed of the comb cylinder in this machine ranges from 90 to 100, according to the quality of staple treated. This machine is especially adapted for combing the shorter staples from the equivalent of G. Middlings American and upwards. Another feature of the machine is the wider range of selection in respect of the length of the fibres rejected. With good staples this can be reduced to as low as 12 per cent. without interfering with the thoroughness of the combing. The piecing is accomplished on a much better principle, and the adjustments are all much simpler than in the machines constructed on the Heilmann system. The production is also considerably greater.

The following are the speeds of the various parts and manner

of ascertaining them by calculation when the comb cylinder makes 100 revolutions per minute :—

$$\text{Machine pulley} = 391\tfrac{7}{23} : \frac{100 \times 90}{23}$$

$$\text{Cam shaft} = 100 : \frac{100 \times 90 \times 23}{23 \times 90}$$

$$\text{Brush cylinder} = 470 : \frac{100 \times 90 \times 24}{23 \times 20}$$

$$\text{Card cylinder} = 3{\cdot}125 : \frac{100 \times 25 \times 1}{25 \times 32}$$

Lap Rollers.

$$\left.\begin{array}{l}\text{Assuming the pawls to move}\\ \text{four teeth per revolution}\\ \text{of the comb cylinder}\end{array}\right\} = 2{\cdot}085 : \frac{100 \times 4 \times 42 \times 35}{75 \times 80 \times 47}$$

$$\text{Ditto five teeth ditto} = 2{\cdot}606 : \frac{100 \times 5 \times 42 \times 35}{75 \times 80 \times 47}$$

NOTE.—The number of teeth moved by the pawls may be adjusted to give the desired length of feed. This is the medium of altering the draft. There are two pawl levers, one actuating the feed and the other the lap rollers, in a similar manner, but separately driven.

Detaching Rollers.—These are actuated through the medium of the quadrant rack and escapement clutch, the movement of the former being communicated to the rollers only when the latter is closed. The quadrant moves up and down seventeen teeth each revolution of the comb cylinder. The clutch escapement is open during a period amounting to eight teeth of the upward movement of the quadrant rack. At this point, in the upward movement, the latter makes a pause to enable the escapement clutch to be closed, and then it resumes the upward movement. This has the effect of turning the detaching rollers backward to the extent of nine teeth of the movement of the quadrant rack. The clutch remains closed during the whole of the downward movement, and hence the detaching rollers are moved backward nine teeth and forward seventeen teeth of the quadrant's action. The pinion engaging the quadrant rack contains thirty teeth, and therefore makes $\frac{17}{30}$ of a complete oscillation each revolution of the comb cylinder; $\frac{9}{30}$ and $\frac{17}{30}$ of this movement are therefore utilized in turning the rollers backward and

forward, respectively. Hence, these movements result in the first detaching roller moving $\frac{9 \times 47}{30 \times 20}$ backward, and $\frac{17 \times 47}{30 \times 20}$ forward, respectively, per revolution of the comb cylinder. This amounts to the following rates per minute:—

$$\text{Backward, } \frac{100 \times 9 \times 47}{30 \times 20} = 70{\cdot}5 \text{ revolutions}$$

$$\text{Forward, } \frac{100 \times 17 \times 47}{30 \times 20} = 133\tfrac{1}{6} \text{ revolutions}$$

the forward progress per minute amounting to $(133\frac{1}{6} - 70{\cdot}5)\frac{9}{10} \times \frac{22}{7} = 177''{\cdot}2$.

The second detaching roller exceeds the movement of the first as 18 : 17 on account of the gear.

These amounts must be regarded as fixed, as adjustments of this gearing are not arranged for.

The combing head calenders are $2\frac{3}{4}$ inches in diameter, and make 19·947 revolutions per minute—

$$\frac{100 \times 48 \times 43 \times 40 \times 16 \times 17 \times 33 \times 20}{24 \times 40 \times 50 \times 25 \times 43 \times 72 \times 20}$$

The revolutions per minute of the first draw roller = 58·645—

$$\frac{100 \times 48 \times 43 \times 40 \times 16 \times 17}{24 \times 40 \times 50 \times 25 \times 30}$$

The revolutions per minute of the second draw roller = 70·374—

$$\frac{100 \times 48 \times 43 \times 40 \times 16 \times 17}{24 \times 40 \times 50 \times 25 \times 25}$$

The revolutions per minute of the third draw roller = 110—

$$\frac{100 \times 48 \times 43 \times 40 \times 16}{24 \times 40 \times 50 \times 25}$$

The revolutions per minute of the fourth draw roller = 277·42—

$$\frac{100 \times 48 \times 43 \times 40}{24 \times 40 \times 31}$$

The revolutions per minute of the draw-box calender = 126—

$$\frac{100 \times 48 \times 43 \times 40 \times 20}{24 \times 40 \times 31 \times 44}$$

The revolutions per minute of the coiler delivery rollers = 179·43—

$$\frac{100 \times 48 \times 43 \times 40 \times 70 \times 20 \times 20}{24 \times 40 \times 55 \times 61 \times 20 \times 20}$$

The revolutions per minute of the coiler = 52·16;
" " can = 6·94—

$$\frac{100 \times 48 \times 43 \times 40 \times 70 \times 20 \times 13 \times 18 \times 18}{24 \times 40 \times 55 \times 61 \times 20 \times 36 \times 36 \times 84}$$

The drafts between the parts in progressive order work out as follows:—

(*a*) Lap and first detaching roller by gear direct. The progressive movement in respect of the detaching roller amounts to 17 − 9 = 8 teeth of the quadrant wheel, or $\frac{8}{30}$ of the 47 clutch wheel which drives that roller, per revolution of the comb cylinder, and therefore—

$\frac{8 \times 47}{30 \times 20}$ = the progressive movement or the amount gained in revolutions of the detaching roller per revolution of the comb cylinder or per nip.

The movement of the lap rollers train of wheels is derived from a pawl moving the ratchet wheel, 75, a certain number of teeth each nip; the extent of this movement can be varied, and is one medium of tensioning the lap. The feed roller is not shown, but it is also worked by a pawl and ratchet, the pawl being operated each nip, and the ratchet wheel is secured upon the feed roller. The movement of the feed roller is adjusted in altering the draft. If the pawl is moved four teeth per nip or revolution of the comb cylinder, the movement of the lap rollers per nip will be the denominator in the succeeding calculations. Hence the draft—

(*a*) By gear direct—

$$= \frac{\dfrac{8 \times 47 \times 9''}{30 \times 20 \times 10}}{\dfrac{4 \times 42 \times 35}{75 \times 80 \times 47} \times 2\tfrac{3}{4}''} = \frac{8 \times 47 \times 9 \times 75 \times 80 \times 47 \times 4}{30 \times 20 \times 10 \times 4 \times 42 \times 35 \times 11} = 9{\cdot}836$$

(*b*) By calculated surface speeds per minute—

$$= \frac{177{\cdot}2}{18{\cdot}02} = 9{\cdot}836$$

The draft between the first and second detaching rollers—

(*a*) $$= \frac{18 \times \frac{9}{10}}{17 \times \frac{9}{10}} = 1{\cdot}058$$

(*b*) $$= \frac{187{\cdot}68}{177{\cdot}27} = 1{\cdot}058$$

The draft between the second detaching rollers and the combing head calenders—

(*a*) $$= \frac{\dfrac{48 \times 43 \times 40 \times 16 \times 17 \times 33 \times 20}{24 \times 40 \times 50 \times 25 \times 43 \times 72 \times 20} \times 2\tfrac{3}{4}}{\dfrac{8 \times 47 \times 18 \times 9}{30 \times 20 \times 17 \times 10}}$$

$$= \frac{48 \times 43 \times 40 \times 16 \times 17 \times 33 \times 20 \times 11 \times 30 \times 20 \times 17 \times 10}{24 \times 40 \times 50 \times 25 \times 43 \times 72 \times 20 \times 4 \times 8 \times 47 \times 18 \times 9}$$

$$= 0{\cdot}916$$

(*b*) $$= \frac{172{\cdot}4}{187{\cdot}68} = 0{\cdot}918$$

The draft between the combing head calenders and the first draw-head roller—

(*a*) $$= \frac{20 \times 72 \times 43 \times 1\frac{1}{8}}{20 \times 33 \times 30 \times 2\frac{3}{4}} = 1{\cdot}28$$

(*b*) $$= \frac{207{\cdot}35}{172{\cdot}4} = 1{\cdot}2$$

The draft between the first and second draw-head rollers—

(*a*) $$= \frac{30 \times 9 \times 8}{28 \times 8 \times 9} = 1{\cdot}2$$

(*b*) $$= \frac{248{\cdot}82}{207{\cdot}35} = 1{\cdot}2$$

The draft between the second and third draw-head rollers—

(*a*) $$= \frac{30 \times 9 \times 8}{17 \times 8 \times 9} = 1{\cdot}764$$

(*b*) $$= \frac{389{\cdot}21}{248{\cdot}82}$$

The draft between the third and fourth draw-head rollers—

(*a*) $$= \frac{25 \times 50 \times 1\frac{1}{4}}{16 \times 31 \times 1\frac{1}{8}} = 2{\cdot}8$$

(*b*) $$= \frac{1089}{389{\cdot}21} = 2{\cdot}79$$

The draft between the fourth draw-head roller and the subsequent calender—

(*a*) $$= \frac{20 \times 2\frac{3}{4}}{44 \times 1\frac{1}{4}} = 1$$

(*b*) $$= \frac{1089}{1089} = 1$$

The draft between the draw-head calender and the coiler delivery rollers—

(*a*) $$= \frac{44 \times 31 \times 70 \times 20 \times 20 \times 2}{20 \times 55 \times 61 \times 20 \times 20 \times 2\frac{3}{4}} = 1{\cdot}035$$

(*b*) $$= \frac{1127{\cdot}8}{1089} = 1{\cdot}035$$

The draft between the lap rollers and the coiler delivery rollers, when the pawl moves 4 teeth per nip—

(*a*) $$= \frac{\dfrac{48 \times 43 \times 40 \times 70 \times 20 \times 20}{24 \times 40 \times 55 \times 61 \times 20 \times 20} \times 2}{\dfrac{4 \times 42 \times 35}{75 \times 80 \times 47} \times 2\frac{3}{4}}$$

$$= \frac{48 \times 43 \times 40 \times 70 \times 20 \times 20 \times 2 \times 47 \times 80 \times 75}{24 \times 40 \times 55 \times 61 \times 20 \times 20 \times 2\frac{3}{4} \times 35 \times 42 \times 4}$$

$$= 62{\cdot}58$$

(*b*) $$= \frac{1127{\cdot}8}{18{\cdot}02} = 62{\cdot}58$$

Draft between the lap and coiler delivery rollers when the pawl moves the feed-ratchet wheel 5 teeth and 8 teeth respectively—

(*a*) $$= \frac{1127{\cdot}8}{22{\cdot}52} = 50{\cdot}08$$

(*b*) $$= \frac{1127 \cdot 8}{36 \cdot 04} = 31 \cdot 29$$

By proportion—

$$\frac{62 \cdot 58 \times 4}{5} = 50 \cdot 07$$

By proportion—

$$\frac{62 \cdot 58 \times 4}{8} = 31 \cdot 29$$

The percentage of waste at this machine is rarely lower than 14 per cent. If 15 per cent. be allowed, and the weight of the laps per yard be each taken as 28 dwts., a machine with 4 heads would produce a sliver weighing $\frac{28 \text{ dwts.} \times 24 \text{ grs.} \times 4 \text{ heads}}{62 \cdot 58} \times \frac{85}{100}$ when the feed pawl moves 4 teeth per nip = 36·51 grs. per yard.

And when the feed is actuated 5 teeth per nip, $\frac{28 \times 24 \times 4}{50 \cdot 08} \times \frac{85}{100}$ = 45·62 grs. per yard.

Note.—The length fed of lap per nip when the pawl moves 8 teeth would be $\frac{36'' \cdot 04}{100} = 0'' \cdot 3604$.

The latter length would prove in most cases an impracticable amount in this machine. It would make the combing action very severe, throwing a great deal more work on the top comb than it is capable of accomplishing. Another way of adjusting the draft in this machine is by changing the wheel compounded with the feed ratchet wheel; this may be called the draft change wheel. Altering this wheel will alter the draft in the inverse ratio, because it will reduce the length feed when it is reduced in size. Changes in the weight of the sliver and the output of the machine may be accomplished by—

(*a*) The draft is altered by the wheel coupled with the ratchet wheel, or by increasing the radius of the pawl lever.

Note.—This wheel can only be altered to a limited extent, owing to its altering the ratio between the lap and the feed rollers; unless the pawl lever, operating the latter, is altered at the same time. The lap is liable to be unduly stretched or puckered if this is not done.

(*b*) Altering the weight of the lap.

(*c*) Altering the length delivered by changing the speed of the machine.

The production in hanks and pounds per week of a Nasmith machine geared as in the figure and having four heads, the comb cylinder making 100 nips per minute, using laps 28 dwts. per yard, the draft 62·58, 15 per cent. being lost in strips, time lost 10 per cent., engine time 55 hours per week, would be computed as follows:—

$$\frac{55 \times 90 \times 60}{100} = \left\{\begin{array}{l}\text{minutes worked per week}\\ \text{less allowances}\end{array}\right.$$

$$\frac{55 \times 90 \times 60 \times 179{\cdot}43 \times 2'' \times 22}{110 \qquad\qquad\qquad 7} = \left\{\begin{array}{l}\text{inches delivered per week by}\\ \text{the coiler delivery rollers}\end{array}\right.$$

$$\frac{55 \times 90 \times 60 \times 179{\cdot}43 \times 2'' \times 22}{100 \times 840 \times 36 \qquad\qquad 7} = \left\{\begin{array}{l}\text{hanks delivered per week by}\\ \text{the coiler delivery rollers}\end{array}\right.$$

$$= 110{\cdot}82$$

$$\frac{\overset{\text{Per cent.}}{90} \times \overset{\text{Revs. P.M.}}{179{\cdot}43} \times \overset{\text{Dia.}}{2''} \times 22 \times \overset{\text{Hrs.}}{55} \times \overset{\text{Mins.}}{60}}{100 \times 36'' \qquad\qquad 7} = \left\{\begin{array}{l}\text{yards delivered by the}\\ \text{coiler delivery rollers}\\ \text{per week, less stoppages}\end{array}\right.$$

$$\frac{\overset{\text{Grs.}}{24} \times \overset{\text{Dwts.}}{28} \times \overset{\text{Laps.}}{4} \times \overset{\text{Per cent.}}{85}}{\underset{\text{Draft.}}{62{\cdot}58} \times 100} = \left\{\begin{array}{l}\text{weight of the sliver in}\\ \text{grains per yard}\end{array}\right.$$

Weight in pounds of the sliver delivered by the machine per week of 55 hours, no allowance

$$= \frac{24 \times 28 \times 4 \times 85 \times 179{\cdot}43 \times 2 \times 22 \times 55 \times 90 \times 60}{62{\cdot}58 \times 100 \times 36 \quad \times \quad 7 \quad \times \quad 100 \times 7000} = 485{\cdot}3$$

The production, in case the feed pawl moved 5 teeth per nip instead of 4, would be—

Weight of the sliver per yard when pawl moved 4 teeth—

$$\frac{4 \times 28 \times 24}{62{\cdot}58} \times \frac{85}{100} = 36{\cdot}5 \text{ grains}$$

Weight of the sliver per yard when the pawl moves 5 teeth—

$$= \frac{36{\cdot}5 \times 5}{4} = 45{\cdot}5$$

Production in pounds per week of 55 hours—

$$\frac{485{\cdot}3 \times 5}{4} = 606{\cdot}5 \text{ lbs.}$$

The length delivered after the alteration would be the same, but the length fed would be one quarter more, and therefore the weight delivered would be proportionately increased.

The production per week, if the feed pawl moved the lap rollers 8 teeth, would be—

$$\frac{485{\cdot}3 \times 8}{4} \text{ lbs.} = 970{\cdot}6$$

EXERCISE 1.—Assuming the speed of the comb cylinder 100 revolutions per minute, and the machine pulleys 14 inches in diameter are changed to $12\frac{1}{2}$ inches, what would be the speeds of each of the parts of the machine?

Answer—

Lap rollers with the pawl moving 4 teeth	2·335
" " " 5 "	3·335
First detaching roller, backward . . .	78·96
" " " forward . . .	149·146
Second " " backward . . .	83·0
" " " forward . . .	157·92
Cam shaft	112
Comb cylinder	112
Machine shaft	$438\frac{6}{23}$
Brush cylinder	404·5
Card "	3·5
Combing head calenders	23·936
First drawing roller	65·682
Second "	78·818
Third "	123·29
Fourth "	310·71
Draw-box calender	141·12
Coiler delivery roller	200·96
Coiler	58·42
Can	7·77

EXERCISE 2.—What would be the consumption of laps and production of sliver, in hanks and pounds, per 50 hours' uninterrupted working of a Nasmith comber, and the weight of the lap per yard; also the percentage of the waste extracted, under the following conditions?—

Sliver produced in 1 minute, 1117 grains.
Strips " " 292 grains.

Weight of the sliver, 40 grains per yard.
Number of combing heads, 4.
Draft in the machine, 50.

Answer—

Length of lap in hanks = 8·328
Weight of laps in pounds = 624·8
Length of sliver in hanks = 104·1
Weight of sliver in pounds = 499·7
Percentage of waste = 20
Weight of the lap per yard = 649 grains.

Exercise 3.—Calculate the amounts of the laps consumed and the sliver produced, in hanks and pounds, if the pawl moved 5 teeth instead of 4, assuming the latter gives 625 lbs. weight of sliver, and the other conditions as given in the answer to the previous question.

$$\frac{625 \times 5}{4} = \frac{3125}{4} = 781{\cdot}25 \text{ lbs. laps}$$

$$\frac{8{\cdot}328 \times 5}{4} = 10{\cdot}41 \text{ hank of lap}$$

The length of the sliver would be unaltered.

The weight of the sliver would be $\frac{499{\cdot}7 \times 5}{4} = 624{\cdot}6$ lbs.

Exercise 4.—What would be the consumption of laps and the sliver produced, in hanks and pounds, per 50 hours' uninterrupted working in a Nasmith comber; also, the percentage of the waste made when the conditions are as follows?—

Production in one minute, 1120 grains of sliver; strips, 280 grains; weight of one yard of sliver, 40 grains; number of combing heads, 4; draft, 50.

Answer—

	Sliver	Laps
Hanks per week	100	8
Pounds ,, ...	480	600

Percentage of the waste, 20

Fig 20 represents the gearing in a single acting combing machine on the Heilmann system.

The object of this machine is to comb the fibres and reject those that are defective and below a specified length.

The cotton is prepared for this process in the same manner as that for the Nasmith combing machine, the range in the weight of the laps for the Heilmann being from 200 to 400 grains per yard, and for the Nasmith about double that weight.

The actions in these two types of combing machines differ, fundamentally, in that the fibres in the Nasmith machine are

only submitted to once combing, whereas in the Heilmann they are submitted a number of times, their introduction to that

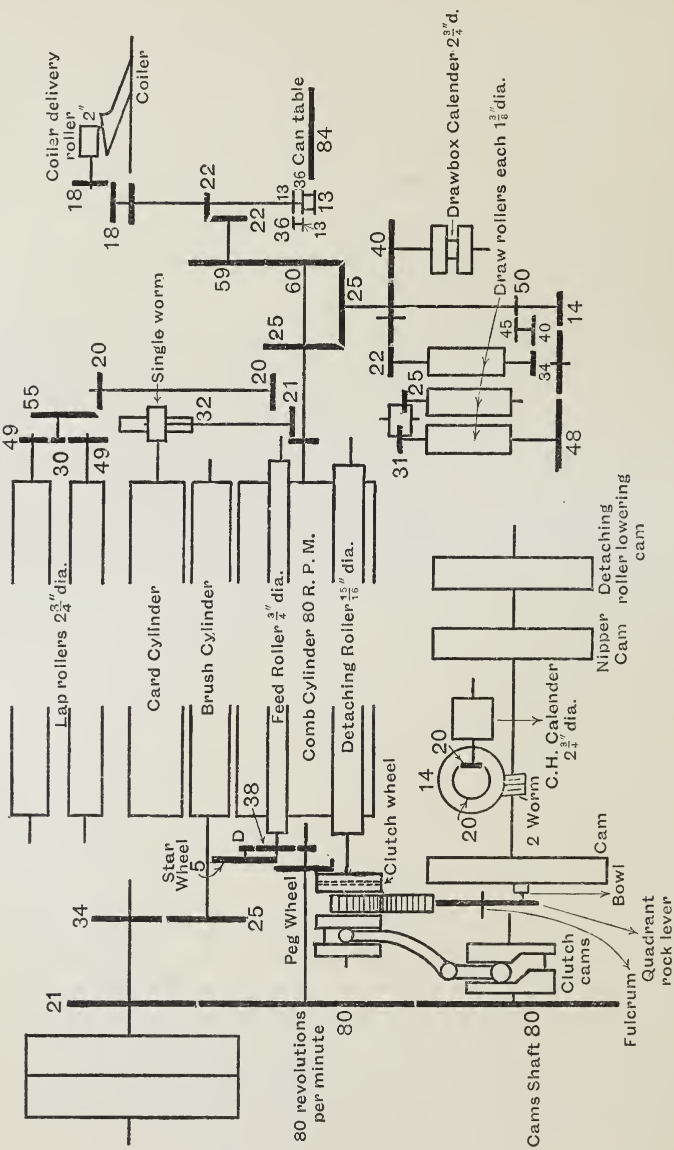


FIG. 20.

action being graduated. The effect of this is that the Heilmann

wields greater powers of discrimination in respect of the length and other features of the fibres selected by it.

The respective parts are named as given in the figure. The revolutions of the comb cylinder range from 60 to 90 per minute. This is often spoken of in terms of nips instead of revolutions, there being one nip or complete cycle of actions per revolution of the comb cylinder in the single acting type. In the Duplex type the cycle of actions are accomplished in each half revolution of the comb cylinder.

The following is the mode of calculating the speeds of the various parts, for this purpose the comb cylinder being assumed to make 80 revolutions per minute :—

Revolutions of machine pulley per minute $= 304\frac{16}{21}$, or, $\frac{80 \times 80}{21}$

Revolutions of lap rollers per minute $= 1{\cdot}77$, or, $\frac{80 \times 1 \times 18 \times 21 \times 20 \times 30}{5 \times 38 \times 20 \times 55 \times 49}$

Revolutions of feed roller per minute $= 7{\cdot}58$, or, $\frac{80 \times 1 \times 18}{5 \times 38}$

Revolutions of comb head calenders per minute $= 11{\cdot}43$, or, $\frac{80 \times 80 \times 2 \times 20}{80 \times 14 \times 20}$

Revolutions of first roller in the draw-box per minute $= 23{\cdot}33$, or, $\frac{80 \times 25 \times 14}{25 \times 48}$

Revolutions of third roller in the draw-box per minute $= 104{\cdot}5$, or, $\frac{80 \times 25 \times 50 \times 40}{25 \times 45 \times 34}$

Revolutions of draw-box calender per minute $= 57{\cdot}5$, or, $\frac{80 \times 25 \times 50 \times 40 \times 22}{25 \times 45 \times 34 \times 40}$

Revolutions of coiler delivery rollers per minute $= 81{\cdot}4$, or, $\frac{80 \times 60 \times 22 \times 18}{59 \times 22 \times 18}$

Revolutions of brush cylinder per minute $= 414{\cdot}4$, or, $\frac{80 \times 34 \times 80}{25 \times 21}$

Revolutions of card cylinder per minute $= 2{\cdot}5$, or, $\frac{80 \times 1}{32}$

Drafts—

Between lap and feed rollers $= 1{\cdot}166$,

or, $\frac{49 \times 55 \times 20 \times \frac{3}{4}}{30 \times 20 \times 21 \times 2\frac{3}{4}}$

Between lap and comb head calenders = 6·45,

$$\text{or, } \frac{49 \times 55 \times 20 \times 38 \times 5 \times 80 \times 2 \times 20 \times 2\frac{3}{4}}{30 \times 20 \times 21 \times 18 \times 1 \times 80 \times 14 \times 20 \times 2\frac{3}{4}}$$

Between lap and first draw roller = 6·58,

$$\text{or, } \frac{49 \times 55 \times 20 \times 38 \times 5 \times 25 \times 14 \times 1\frac{3}{8}}{30 \times 20 \times 21 \times 18 \times 1 \times 25 \times 48 \times 2\frac{3}{4}}$$

Between lap and third draw roller = 29·51,

$$\text{or, } \frac{49 \times 55 \times 20 \times 38 \times 5 \times 25 \times 50 \times 40 \times 1\frac{3}{8}}{30 \times 20 \times 21 \times 18 \times 1 \times 25 \times 45 \times 34 \times 2\frac{3}{4}}$$

Between lap roller and draw-box calender = 32·5,

$$\text{or, } \frac{49 \times 55 \times 20 \times 38 \times 5 \times 25 \times 50 \times 40 \times 22 \times 2\frac{3}{4}}{30 \times 20 \times 21 \times 18 \times 1 \times 25 \times 45 \times 34 \times 40 \times 2\frac{3}{4}}$$

Between lap and coiler delivery rollers = 33·4,

$$\text{or, } \frac{49 \times 55 \times 20 \times 38 \times 5 \times 60 \times 2 \times 22}{30 \times 20 \times 21 \times 18 \times 1 \times 59 \times 22 \times 2\frac{3}{4}}$$

Between first and second draw rollers—

$$\frac{31 \times 1\frac{3}{8}}{25 \times 1\frac{3}{8}} = 1{\cdot}24$$

Between first and third draw rollers—

$$\frac{48 \times 50 \times 40 \times 1\frac{3}{8}}{14 \times 45 \times 34 \times 1\frac{3}{8}} = 4{\cdot}48$$

Between second and third draw rollers—

$$\frac{25 \times 48 \times 50 \times 40 \times 1\frac{3}{8}}{31 \times 14 \times 45 \times 34 \times 1\frac{3}{8}} = 3{\cdot}6$$

Between third draw roller and draw-box calender—

$$\frac{22 \times 2\frac{3}{4}}{40 \times 1\frac{3}{8}} = 1{\cdot}1$$

Between draw-box calender and the coiler delivery rollers—

$$\frac{40 \times 34 \times 45 \times 25 \times 60 \times 22 \times 18 \times 2}{22 \times 40 \times 50 \times 25 \times 59 \times 22 \times 18 \times 2\frac{3}{4}} = 1{\cdot}025$$

The movement of the detaching rollers is derived as follows: The quadrant rack is a part of a lever actuated by a bowl projecting from it into a cam. The rising and falling movement

of the quadrant rack is about 12 teeth, so that the 14 wheel receives movement equal to $\frac{12}{14}$ of a revolution per (nip) revolution of the cam shaft. The cam on the left hand engages and disengages the escapement clutch, and by this means the difference in the extent of the backward and forward rotation of the detaching rollers is obtained. The clutch is open during the first five teeth of the upward movement of the quadrant rack; after that movement the quadrant rack pauses to allow the clutch to be engaged, and upon the resumption the detaching rollers commence their backward movement—this is a constant amount, and is equal to seven teeth of the rack pinion. The clutch remains engaged during the whole of the downward movement of the rack, and therefore the backward and forward movements of the detaching roller amount to $\frac{7}{14}$ and $\frac{12}{14}$ of a revolution respectively. This difference in the movements is insufficient to provide the necessary overlay for piecing. Further variations are obtained, to any extent within these limits, by deferring the placing of the leather detaching roller upon the fluted segment until the length of those fibres, already within the nip of the detaching roller, project only sufficent for the necessary overlap.

It must be noticed that variations in the overlap cannot be obtained by altering the timing of the closure of the clutch cam. The clutch cam can only be satisfactorily closed at the moment that the pause occurs in the upward movement of the quadrant rack. Closure at any other period will result in damage to the clutch.

Notes respecting the Permissible Adjustment in the Drafts.— The drafts between the lap and feed rollers, detaching rollers and head calenders, head calenders and first draw rollers, third draw roller and draw-box calender, draw-box calender and the coiler delivery rollers, must always be such that the cotton is in slight tension without straining.

The point admitting of variations in the draft is therefore between the feed and detaching rollers. Alterations in this alter the character of the combing, because it is accomplished by introducing the fibres more or less gradually, and hence the number of combing actions which they are subjected to is altered thereby.

Feeding a considerable length of lap generally results in greater waste; hence, light laps and low drafts together are not beneficial.

Moderately high drafts—provided the fringe of the lap is well held by the nippers and the more numerous combings are not injurious—are conducive to better selection of the fibres.

The weight a machine is required to comb always decides the count of the combed sliver.

The length of the staple decides the suitable speed.

Results must always decide the weight of the lap as its state as well as that of the machine differ so much.

The waste made ranges from 15 per cent. upwards, according to the state of preparation of the laps, the amount of short fibre which it contains, and the settings.

With laps each weighing 240 grains per yard, a machine, containing six combing heads and a total draft of 33·4, the loss in waste being 18 per cent., would make sliver weighing—

$$\frac{240 \times 6}{33{\cdot}4} \times \frac{82}{100} = 36{\cdot}5 \text{ grains per yard}$$

The percentage of the waste is always based upon the weight of the feed.

The weight of the waste and of the sliver, delivered per unit of time, together, equal the weight of the cotton fed in that time.

These machines usually contain six or eight combing heads, and therefore the amount fed is always that number multiplied by the average weight per unit of length of the lap fed, whilst the length delivered exceeds that fed, in one head, in the terms of the total draft.

Exercise 1.—The sliver and the waste produced in a given time weigh respectively 520 and 130 grains, the waste discharged by the six combing heads weighing 20, 20, 21, 22, 23, and 24 grains. Give the individual and total percentage of the loss at each head.

Exercise 2.—The sliver produced by a combing machine having six heads is at the rate of 8 lbs. per head per 10 hours. The total draft is 32, and the waste made in that period weighs 10·2 lbs. What is the percentage of the waste made, the weight in pounds, and the length in yards of the laps consumed?

Exercise No.	Weight per yard of each lap fed, in grains.	No. of combing heads.	Total draft.	Size of the draft-change wheel.	Percentage of waste extracted.	Weight of the sliver in grains per yard.	Revolutions per minute of the coiler delivery rollers (2″ diameter).	Revolutions of the comb cylinder per minute.	Production in pounds per hour uninterrupted working.	Answers respectively.
3	240	6	33·4	18	18	?	81·4	80	?	36, 4·38
4	264	6	33·4	18	18	?	81·4	80	?	39·6, 4·82
5	264	6	?	14	18	?	81·4	80	?	43, 30·8, 3·75
6	288	6	40·0	?	20	?	81·4	80	?	15, 34·5, 4·21
7	?	6	43·0	14	20	32·0	81·4	80	3·9	183
8	?	6	43·0	14	20	32·0	?	75	?	287, 76·3, 3·66
9	288	6	37·6	?	?	38·6	85·5	84	4·94	16, 16, 85·5, 4·94
10	240	6	37·6	?	18	?	85·5	?	?	
11	240	6	?	?	20	41·2	85·5	84	?	

Exercise 12.—If the machine pulleys in the last question, 15 inches in diameter, are changed to 16 inches in diameter, what difference in the weight of combed sliver, waste, and laps would result?

The Drawing Frame.

The object of this process is the elimination of the irregularities, found in the weight of the sliver, at this stage. This is accomplished by repeating the process of aggregation and attenuation. In this process there are usually three repetitions, but sometimes two or four are adopted, the former in coarse, and the latter in fine, work. Repetition of the process should be discontinued when the desired standard of uniformity is attained. The heads are numbered corresponding with the repetitions respectively. Thus a draw frame of three heads means that the cotton is treated to aggregation and attenuation three times, namely: in the first, second, and third heads. It is necessary to test the sliver, preferably at the last head, at frequent and fixed intervals, four times per day at least, so that any deviation from the standard weight may be detected and dealt with. The tests should be recorded along with the precautionary or corrective measures taken in instances of variation. In these tests, 5, 6, or 15 yards will be found convenient lengths to wrap. The sliver tested should be taken in a manner ensuring correct representation of the prevailing condition, the best way being to take a little from each delivery, but not off full cans. The weight is liable to frequent variation at this stage; the cause of this is not always apparent. The variations foreshadow the working qualities of the cotton and irregularities in the treatment prior to this stage.

When variations are disregarded, more than corresponding differences may be expected in the subsequent processes, and often complications of an involved character arise through these faults being unchecked.

During very dry weather the wrappings tend to the heavy side. A sudden change in the atmosphere will sometimes necessitate an alteration of quite a few teeth in the change wheel. Changes in the mixing which result in the cotton differing are similarly liable. Cottons which are softer than usual should

be kept on the heavy side, and *vice versâ*. It is also advisable to keep the change wheel as large as convenient. By noting at the commencement of new mixings the quantities and character of the new lots of cotton contained in them, the space occupied by the scutcher laps, and the waste made in carding, it is possible to discern features that are likely to develop in the subsequent stages. These, together with the tests of the sliver at the third head of the drawing-frame provide a good index of the subsequent working capacities of the cotton.

The cans should be "put up" systematically at the feed of each head, the aim being to obtain like conditions at each delivery. "Putting up" more than one full can per delivery is detrimental.

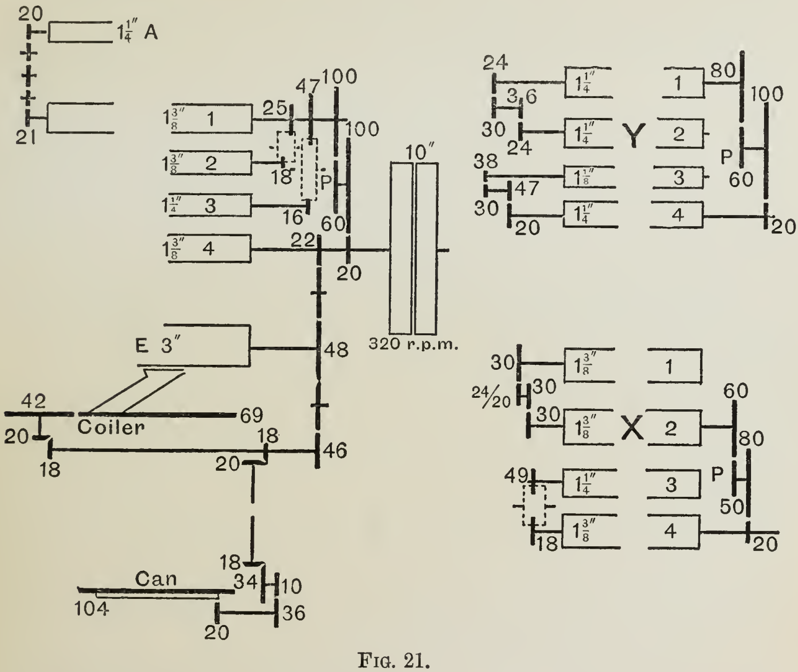


FIG. 21.

Calculations relating to Draw Frames (Fig. 21).—*Drafts between the Various Parts.*—Lifting roller A and No. 1 draw roller—

$$\frac{20 \times 1\frac{3}{8}}{21 \times 1\frac{1}{4}} = 1{\cdot}047$$

Nos. 1 and 2 draw rollers—

$$\frac{25 \times 1\frac{3}{8}}{18 \times 1\frac{3}{8}} = 1{\cdot}39$$

Nos. 2 and 3 draw rollers—

$$\frac{18 \times 47 \times 1\frac{1}{4}}{25 \times 16 \times 1\frac{3}{8}} = 1{\cdot}925$$

Nos. 1 and 3 draw rollers—

$$\frac{47 \times 1\frac{1}{4}}{16 \times 1\frac{3}{8}} = 2{\cdot}67$$

Nos. 3 and 4 draw rollers—

$$\frac{16 \times 100 \times 100 \times 1\frac{3}{8}}{47 \times 60 \times 20 \times 1\frac{1}{4}} = 3{\cdot}12$$

Nos. 1 and 4 draw rollers—

$$\frac{100 \times 100 \times 1\frac{3}{8}}{60 \times 20 \times 1\frac{3}{8}} = 8{\cdot}33$$

No. 4 draw roller and coiler delivery roller E—

$$\frac{22 \times 3}{48 \times 1\frac{3}{8}} = 1$$

Lifting roller and coiler delivery rollers, A and E, the total draft—

$$\frac{20 \times 100 \times 100 \times 22 \times 3''}{21 \times 60 \times 20 \times 48 \times 1\frac{1}{4}''} = 8{\cdot}75$$

There is much difference of opinion in regard to the system of allocating the draft in the draw rollers of drawing frames which gives the best results. The following has proved a good rule, and is in accordance with the working conditions:—

Draft between first and second draw rollers: not more than 1·2

,, second and third ,,

$$\sqrt[3]{\frac{\text{draft between first and fourth}}{1{\cdot}2}}$$

,, third and fourth draw rollers: (draft between the second and third rollers)^2.

EXAMPLE.—Thus, if the total draft in the draw rollers = x, and that between

the first and second x_1, that between the second and third x_2, and that between third and fourth x_3 (x in the figure $= 8{\cdot}33$)—

$$\text{then, } x = x_1 \times x_2 \times x_3$$
$$\text{since } x_1 = 1{\cdot}2$$
$$\therefore x_2 \times x_3 = \frac{x}{1{\cdot}2} = \frac{8{\cdot}33}{1{\cdot}2} = 6{\cdot}95$$
$$x_2 = \sqrt[3]{\frac{x}{1{\cdot}2}} = 1{\cdot}91$$
$$x_3 = \left(\sqrt[3]{\frac{x}{1{\cdot}2}}\right)^2 = 3{\cdot}65$$

The draft x_2 is, in most makes of these machines, inconvenient for changing. Changes in this are only necessary when the total draft referred to becomes abnormal. With this draft x_2 regarded as fixed, the defects arising are through the draft x_3 approaching in amount that of x_2; when the total roller draft is reduced to 4·38, then x_2 and x_3 are alike.

It must not be inferred from the latter statement that a change of the draft between the first and third rollers is advocated whenever the total roller draft is altered. It is only desired to point out the error arising when considerable change is made in the total draft, and the expediency of affording relief by a slight alteration in the draft between the first and third, in order to redistribute the drafts in reasonable proportions.

It is necessary also to draw attention to the desirability of using change wheels of moderate size, avoiding small ones.

$$\left.\begin{array}{l}\text{The revolutions of}\\\text{the coiler per minute}\end{array}\right\} = 320 \times \frac{22 \times 18 \times 42}{46 \times 20 \times 69} = 83{\cdot}84$$

$$\left.\begin{array}{l}\text{The revolutions of}\\\text{the can per minute}\end{array}\right\} = 320 \times \frac{22 \times 18 \times 18 \times 10 \times 20}{46 \times 20 \times 34 \times 36 \times 104} = 3{\cdot}9$$

Whenever draw frames are changed from heavy slivers, to the other extreme, the coils are frequently ill-spaced in the can, and *vice versâ*. This may be remedied by remembering that heavy sliver requires more space, and hence higher speeds of the can than light fine slivers.

When the sliver is coiled too widespread it is liable to be troublesome through too much tension caused by binding in the can. This may be overcome by slightly increasing the rate

of the coiler. On the other hand, when the sliver is not fully distributed—indicated by a wide space between it and the can side—the cans cannot contain as much as desirable. This may be overcome by slightly reducing the rate of the coiler. When the unoccupied space in the centre of the can is greater than desired, it is due to the can being "too eccentric" with the coiler. By reducing this, and at the same time the rate of the coiler, this objection may be removed.

The quantity of the production in draw frames varies according to the speed, the system, and the efficiency of the workers. In some mills, as high as 90 per cent. of the production, calculated from the actual speeds, are obtained with slivers as high as 70 grains per yard.

The above may be considered practicable under the best conditions. This would give the following, per delivery, in a week of $55\frac{1}{2}$ hours:—

Revolutions of front roller.	Weight of sliver in grains per yard.	Hanks per delivery.	Pounds per delivery.
320	50	137·19	823
„	55	„	905
„	60	„	987
„	65	„	1070
„	70	„	1152

Productions for Speeds ranging from 320 up to 380 Revolutions per Minute of $1\frac{3}{8}$-inch Front Roller.

Revolutions of front roller per minute.	Weight of sliver in grains per yard.	Production in pounds per week.
320	70	1152
330	„	1198
340	„	1234
350	„	1270
360	„	1306
370	„	1337
380	„	1366

In medium fine (50^s–80^s) counts, the former of the above speeds and productions would be considered ample, and the sliver would range from 50 grains per yard downwards, according to

quality of the yarn and the quantity of preparation machinery available.

Revolutions of front roller per minute.	Weight of sliver in grains per yard.	Production in pounds per week per delivery.
320	50·0	823
„	47·5	783
„	45·0	744
„	42·5	704
„	40·0	765
„	37·5	726
„	36·0	687

In fine counts, 80^s upwards, the speeds would range from 280 downwards, and the rollers would be $1\frac{1}{2}$ inches in diameter in three positions instead of $1\frac{3}{8}$ inches, and the slivers down to 24 grains per yard. The productions are—

Revolutions of front roller per minute.	Weight of sliver in grains per yard.	Production in pounds per week per delivery.
$280 \times 1\frac{1}{2}$ F.R.	36·0	658
„	33·0	603
„	30·0	548
„	27·0	493
„	24·0	438

Calculations relating to the Drafts in the Rollers (Fig. 21, Y).

Between—

First and second $= \dfrac{24 \times 36}{30 \times 24} = 1{\cdot}2$

Second and third $= \dfrac{24 \times 30 \times 80 \times 100 \times 20 \times 30 \times 9}{36 \times 24 \times 60 \times 20 \times 47 \times 38 \times 10} = 1{\cdot}68$

Third and fourth $= \dfrac{38 \times 47 \times 10}{30 \times 20 \times 9} = 3{\cdot}30$

First and fourth $= \dfrac{80 \times 100}{60 \times 20} = 6{\cdot}\dot{6}$

First and third $= \dfrac{80 \times 100 \times 20 \times 30 \times 9}{60 \times 20 \times 47 \times 38 \times 10} = 2{\cdot}01$

Notes in respect of this System of Gearing Rollers.

(*a*) That, since P is the customary change wheel for varying the total extent of the attenuation and the weight unit of the sliver produced, any alteration of P or of the back roller wheel disturbs the draft between rollers 2 and 3 only, and if the total draft be altered by this means gradually to 3·968, that between 2 and 3 would be gradually diminished, no attenuation would then take place between those rollers, and if altered to less than that amount contraction instead of attenuation of the sliver must result between those points.

(*b*) The draft between the rollers 3 and 4 would, under the circumstances mentioned in paragraph (*a*), always be constant, and hence should the wheels be altered to exercise a greater draft than $6 \cdot \dot{6}$, the draft between the second and third rollers only would be increased. Thus, in case the total draft was raised to 11·9, the draft between the second and third rollers would then become as much as that between the third and fourth.

By this system of gearing the variable draft is placed at a point which is not the best. This also may be said of system X (Fig. 21), with this addition, that there is room for error in calculation by overlooking that the two trains—eight wheels—are involved in the calculation of the total draft. Another feature in these systems of gearing (Y and X) is the backlash due to the increased number of wheels and indirectness of the gear. This is best understood when the effects upon the sliver are considered with the wheels loosely geared or worn. On reference to the gearing it will be seen that 3 will start after 4, and 2 considerably after this, because in the former there are only three or four wheels against eight in the latter.

The system of driving the (2) and (3) rollers direct from the back roller as shown in the other figure has many advantages over X and Y. It ensures the variable draft between those rollers having the lightest work to perform, greater facilities for changes and calculations; occupies less space, simplifies the parts, fewer wheels are required, and permits the use of larger wheels.

Exercises.—Calculate the drafts in Fig. 21 between—

(*a*) 1 and 2, 2 and 3, 3 and 4, 1 and 3, 1 and 4, 2 and 4, when the compound wheel between 1 and 2 is 20 and 30.

(*b*) 1 and 2 when the wheel marked 20 is 21, 22, 23, and 24 respectively.

(*c*) 1 and 4 when the wheel marked 20 is 21, 22, 23, and 24 respectively.

(*d*) 1 and 4 when P is the inclusive sizes from 40 to 60.

(*e*) 2 and 3 when P is the inclusive sizes from 40 to 60.

(*f*) 1 and 4 when the 60 on the roller 2 is 40, 50, 70, 80.

(*g*) What should be the weight, in grains per yard, and count of the sliver delivered, in each of the three types of gearing given, if the number of slivers fed per delivery were in each case six, and each of these weighed at the rate of 48 grains per yard?

(*h*) If the sliver delivered by a machine, geared as in Fig. 21, weighed 54 grains per yard, what should it weigh if the wheel P was successively 40, 45, 50, and 55 respectively?

(*i*) What would be the production in pounds per delivery per week with P 40, 45, 50, and 55 respectively, if with a 60, P, 1152 lbs. were produced?

The Arrangement of the Drafts in the Several Heads constituting the Draw Frame.—The condition which should govern the extent of the total drafts allotted to each head is that each should be so rated as to be continuously working without producing more or less than is required by the succeeding machine.

It is the most common practice to have the same number of deliveries in each head, and also for the front rollers in these to revolve at the same rate. Practice has proved this most expedient. To get the best results under such conditions, arrange the drafts so that the condition contained in the last paragraph may be realized.

The variations in the contents of the cans from the cards occasion considerably more loss of time in the first head, through stoppages, taking this at 10, 7, and 7 per cent. respectively in the three heads, and the revolutions of the front roller at 320 per minute and $1\frac{3}{8}$ inches in diameter, the card sliver at 36 grains per yard, and that at the last head at, say, 60 grains per yard. Then the productive capacity of the third head would amount to—

$$\frac{55 \text{ hrs.} \times 60 \times 320 \times 1\frac{3}{8}''}{36 \times 7000} \times \frac{22}{7} \times \frac{60}{1} \times \frac{93}{100} = 1000 \text{ lbs. per delivery}$$

Hence, the front roller in the second head would require to produce sliver at the same rate per yard, whilst that delivered

by the first head would require to be heavier to the extent of the difference in the loss of time, and therefore—

$$\frac{60 \times 93}{90} = 62 \text{ grains per yard}$$

The draft in the respective heads on the assumption that the doublings are 6, in each case must therefore be

In the first head—

$$\frac{36 \times 6}{\text{draft}} = 63$$

$$\therefore \text{ draft} = \frac{216}{63} = 3{\cdot}43$$

And in the second head—

$$\frac{62 \times 6}{\text{draft}} = 60$$

$$\therefore \text{ draft} = \frac{372}{60} = 6{\cdot}2$$

And in the third head—

$$\frac{60 \times 6}{\text{draft}} = 60$$

$$\therefore \text{ draft} = \frac{360}{60} = 6$$

Fly Frames.

The primary object in fly frames—slubber, intermediate, rover, and jack—is to attenuate the sliver obtained from the drawing frame to the extent necessary to prepare it for the spinning machine.

It would be possible to dispense with fly frames if drawing rollers were perfectly adapted for attenuating cotton. Drawing rollers, as at present constructed, cannot attenuate perfectly bodies of fibres varying in length. Cotton cannot be obtained which does not vary in the length of its fibres. In consequence, the relative sequence of the fibres is altered during attenuation in a degree proportionate to those variations and the extent of the attenuation attempted. This means, that a sliver or rove with its fibres uniformly distributed would have its fibres

otherwise arranged. The less the variation in the length of the fibres the greater the draft practicable.

Repetition of these processes is necessitated to admit of doubling and thereby absorption of the irregularities referred to. There is no doubt that doubling of more than two ends would be advantageous. The difficulties connected with presenting more than that number are the most likely reason of its not being adopted.

The Object of Twisting.—Twisting assists cohesion, and is employed to the extent sufficient to protect the bodies of fibres at these stages.

The Direction of Twist and the Range of Usefulness of Twist.—The rule in respect of the direction of the twist, in rove, is

twist; although there are instances of weft twisting.

The direction of the twist has a slight influence on the spinning: a twist rove makes better and stronger yarn when it is twisted finally in the same direction than when this is done reversely. It is undoubtedly the case that roving twisted in the same direction as the ultimate yarn, would secure better results in spinning. The only reason which can be given for this not being practised, in respect of weft and "reverse" yarns, is that it may not be so convenient to produce on account of necessitating the use of the left hand in piecing. It is advantageous, in preparing roving for twist yarn in ring frames, to use the maximum, and for weft or reverse yarn the minimum twist, constants. Twist has a beneficial influence, when it is in the same direction as that required in the yarn, and when not used to excess. The reason for many carders preferring the minimum twist is because it enables a greater production, from their point of view, but this is not the case with the spinner. Roving may contain too little twist without breaking in the creel. Care should always be exercised to avoid twisting to the extent which may bind the fibres in excess, causing them to withstand the subsequent attenuating powers.

Twist Constants.—The efficacy of twist varies in the various grades and kinds of cotton; it is also influenced by the degree

of uniformity of the length of the fibres and touch of the cotton. The amount of the twist per inch necessary to bind the fibres to the proper extent varies from $\sqrt{\text{count}} \times 0{\cdot}8$ to $\sqrt{\text{count}} \times 1{\cdot}5$. Cottons which are long and harsh and lie compactly require least, whilst those which are short and do not lie compactly require most, twist.

The following is a table of the normal twist constants. These, when multiplied by the $\sqrt{\text{counts}}$ of the actual rove, will give the twist per inch suitable under most conditions.

		Slubber.	Inter.	Rover.
Sea Island and Egyptian cottons . .	from :	0·8	0·9	0·9
	to :	1·0	1·1	1·2
Brazilian, American, and similar cottons	from :	1·0	1·1	1·2
	to :	1·2	1·25	1·3
Indian and similar cottons	from :	1·1	1·2	1·4
	to :	1·2	1·4	1·5

The Gearing in Fly Frames (Fig. 22).—The gearing in fly frames is identical in all the principal makes. It consists of a principal shaft called the frame shaft, and from this all the parts receive their motion.

(*a*) **The Rollers.**—The front roller is connected with the frame shaft referred to by means of a train consisting of four or five wheels, F, E, D, C, B, named, respectively: the twist, the twist carrier or compound, the top cone, the end of top cone, and the end of the front roller wheels; a compound wheel instead of E being necessary when considerable range of twist are necessary. The back and middle rollers are connected with the front in the following manner: a train of four wheels, 28, 90, 40, 56, and named respectively the front roller (F.R.W.), the crown (C.W.), the pinion (P.W.), and the back roller wheels (B.R.W.); these comprise the connection to the latter roller, the crown and pinion being compounded. The middle roller is connected with the back through the medium of three wheels, 25, C, 18; they are named the back roller (driver), carrier, and middle roller wheels.

(*b*) **The Spindles.**—The shafts driving these, one only is shown, are connected by a train of three wheels, 33, H, 33, in case of the back line of spindles; and a fourth wheel on the front shaft gears with that on the shaft driving the back line of spindles.

These spindle shafts are furnished with skew bevels, 60, and these drive the bevels, 21, on the spindles. The value of this train is fixed.

(*c*) **Winding.**—*The Bobbins* are driven from two points upon the frame shaft, T.W. and M, the motion from these two points being brought together at the terminal wheel, 14, in the differential. The bobbin driving shaft (O) is connected with the sleeve wheel of the differential N, by means of four or five wheels

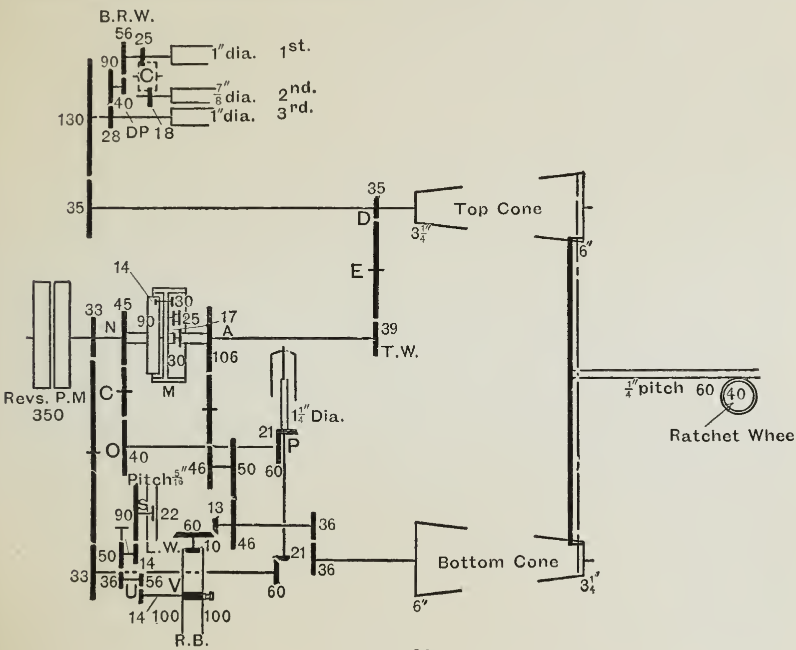


Fig. 22.

in case of the front, and three or four, 45, C, 40, in case of the back bobbin shaft. These wheels are known as the swing train. The sleeve N acquires its motion from the two points, receiving a fixed contribution from one, M; and a variable contribution from A, the other of these two points; the fixed portion here referred to being contributed by that part of the differential which is fixed to the jack shaft. In some cases that part is a wheel. The variable contribution is received by the differential from the twist wheel, T.W., on the frame shaft, the motion passing through the top and bottom cones, and thence through a

train consisting of a varying number of wheels, numbered on the figure 36, 36, 46, 50, 46, 106. The fixed contributor is arranged to supply the movement necessary to rotate the bobbins at the same rate as the spindle; the variable contributor communicating only that necessary to obtain winding at the desired tension. By this arrangement, the cones completely control the winding. When they cease to contribute, winding ceases; through the bobbins then assuming the rate of the spindles. The wheels in this latter connection are known by the following names: the bottom cone, change shaft, winding shaft, differential, differential sleeve, swing, bobbin shaft, skew bevels, and bobbin wheels.

The Consequences of altering the Value of the Cone Train.—The value of the wheel train, connecting the fixed contributor with the bobbins, should be a constant, and therefore any departure from the above-named conditions will result in imperfect winding. The value of the wheel train connecting the twist wheel with the differential should likewise be constant. The value of the belt connection on the two cones is the medium for providing the acceleration or retardation of the bobbin necessary to obtain the proper winding tension; this being a plus or minus contributor according to the conditions of winding adopted. The two conditions in respect of winding, referred to, are bobbin lead and flyer lead. In the former of these the winding is occasioned by the excess in the rotation of the bobbin over that of the flyer; and *vice versâ* in flyer lead. In flyer lead the bobbin must be accelerated to the extent coincident with the proportional change in the size of the bobbin at the commencement of each new layer of coils, but only in respect of that portion of their motion supplied through the medium of the cones. In bobbin lead retardation takes the place of acceleration. The connection of the front roller with the bobbins is, therefore, such that the latter creates a winding rate coinciding with the rate of delivery by former. Any change in the rate of rotation of the front roller obtains a corresponding change in the winding rate.

The cone drums are constructed to comply with the requirements of certain sizes of bobbins, each portion being adapted for a certain size, and that only. Altering the value of this

train of wheels is most likely to place the cone strap on a wrong part of the cones. There is only one part that will give the fractional change of speed corresponding with the fractional increase that each added layer bears to the size of the surface it is laid upon. If the strap is not on that portion of the cones, then the tension of winding will be inaccurate.

(*d*) **The Spacing of the Coils.**—This is obtained by the movement of the bobbin, vertically, past the guiding point of the flyer. This raising and lowering movement of the bobbin is derived also from the twist wheel, through the cones, by a connecting train intercepting the train between the bottom cone and the differential connections, namely, 13, 60, (W), 10, 100, (V), 14, 56, (U), 36, 50, (T), 14, 90, (S), 22. The necessity for this vertical movement being derived from the cones arises through the number of coils wound retarding at a rate inverse to the increasing size of the bobbin. The number of wheels employed in this connection vary somewhat. The reversion in the direction of the vertical movement is obtained by means of R.B., the reversing bevels; these alternately engage their driving bevel.

The wheels in this connection are known by the following names: Top change, top of upright, strike bevel, reversing bevels, reversing bevels shaft, cannon shaft, bottom change shaft, lifting shaft wheels, and lifting racks.

Speeds of the Parts in Fly Frames.

Subject.	Details of calculation (Fig. 22).	Revolutions per minute.	Surface rate in inches per minute.
Front roller, B	$\frac{350 \times 39 \times 35}{35 \times 130} =$	105	
	$\frac{105 \times 1'' \times 22}{7} =$		330″
Spindles, P . .	$\frac{350 \times 33 \times 60}{33 \times 21} =$	1000	
Twist per inch	$\frac{\text{revolutions of spindle per minute}}{\text{inches del. by the F.R. per minute}} = \frac{1000}{330''} = 3{\cdot}0\dot{3}$		
Twist constant	$= \frac{\text{twist per inch}}{\sqrt{\text{count}}}$ *Note.*—Count suitable depends upon the twist constant used.		

Subject.	Details of calculation (Fig. 22).	Revolutions per minute.	Surface rate in inches per minute.
Top cone (C, D)	$\frac{350 \times 39}{35} =$	390	
Bottom cone, Y	Assuming the strap on the parts 6″ top cone and 3¼″ bottom cone— $\frac{350 \times 39 \times 6}{35 \times 3\frac{1}{4}} =$	720	
	Assuming the strap on the parts 3¼″ diameter top cone and 6″ diameter bottom cone— $\frac{350 \times 39 \times 3\frac{1}{4}}{35 \times 6} =$	211·2	
Draft between the back and front rollers (1st and 3rd)	$\frac{56 \times 90 \times 1''}{40 \times 28 \times 1''} = 4{\cdot}5$	Ratio 1 : 4·5	
Bobbin lifting shaft, S	$\frac{350 \times 39 \times 6 \times 36 \times 13 \times 10 \times 14}{35 \times 3\frac{1}{4} \times 36 \times 60 \times 100 \times 56} \times \frac{36 \times 14}{50 \times 90} =$	0·437	3
	Note.—The above is when cone strap is assumed in positions 6″ in diameter driver cone and 3¼″ in diameter driven cone. And when cone strap is in positions, respectively, 3¼″, 6″— $\frac{350 \times 39 \times 3\frac{1}{4} \times 36 \times 13 \times 10 \times 14}{35 \times 6 \times 36 \times 60 \times 100 \times 56} \times \frac{36 \times 14}{50 \times 90} =$	0·128	0·88
Bobbin . . .	To wind without stretching, assuming the winding circle 1¼″ in diameter and bobbin lead— $\frac{330}{1\frac{1}{4} \times \frac{22}{7}} + 1000 =$	1084	330″ in excess of flyer presser
	If flyer lead— $1000 - \frac{330}{1\frac{1}{4} \times \frac{22}{7}} =$	916	330″ slower than flyer pressure
	Maximum size of bobbin that the cones are adapted for— $= 1\frac{1}{4} \times \frac{6 \times 6}{3\frac{1}{4} \times 3\frac{1}{4}} = 4{\cdot}25''$		
	When the bobbin is the maximum size, 4¼″, and bobbin lead— $1000 + \frac{330}{4\frac{1}{4} \times \frac{22}{7}} =$	1024·7	
	If flyer lead— $1000 - \frac{330}{4\frac{1}{4} \times \frac{22}{7}} =$	975·3	
	For calculations of the speeds of the bobbins as per gearing, see p. 127.		

The Change Wheels in the afore-mentioned Trains respectively.—The following are the customary change wheels :—

(*a*) For altering the rate of the rollers relative to the spindles and thereby the twist—twist, compound, and top cone shaft wheels, in the order named.

For altering the total draft or the attenuating powers of the rollers—pinion, back roller, crown, and front roller wheels.

For altering the drafts between the individual rollers, the small wheels on the back or middle roller.

(*b*) None of the wheels in this train are altered.

(*c*) For altering the tension of winding. This should be done by the ratchet wheel or adjusting the position of the cone strap forks. The practice of changing one of the wheels in this train, connecting the differential, which is generally recognized, is open to serious objections, which are stated in the section dealing with winding, p. 127.

(*d*) For controlling the spacing of the rove upon the bobbin. The lifter change shaft wheel and strike bevel are the usual change points.

Alterations in the Draft.—Alterations in the draft are necessary when the count, or the weight per unit of length, are not as desired. Also, when a change is made in the feed, and a corresponding change in the delivery is not required.

The formula when changing the draft or the counts, is—

$$\frac{\text{Present draft} \times \text{count desired}}{\text{present count}} \times \frac{\text{count of present feed}}{\text{count of distended feed}} = \left\{\begin{array}{c}\text{draft} \\ \text{required}\end{array}\right.$$

When the weight takes the place of the count, it is necessary to bear in mind that the weight is inverse to the count, and that this necessitates the inversion of the two terms, desired and present, in the above equation.

The total roller draft may be altered by changing the size of any of the four wheels in the train connecting the back with the front roller. The pinion wheel is the recognized change wheel, and the back roller wheel is changed when the limits in respect of the former have been reached. When the limits of the two former are exhausted the crown wheel is changed, but this is not often necessary.

Changes in the count delivered may be made by varying the count of the feed or the draft in the direct proportion.

Changes in the count fed may be checked by inverse changes in the draft.

Changes in the sizes of the drivers, in the draft train of wheels, obtain inverse changes in the draft and count, and direct changes in the weight per unit of length.

Changes in the sizes of driven wheels in the draft train have the inverse effect to the drivers.

Alterations in the Draft, how made.—Changes in the draft, or in the count produced, do not affect the extent of the length delivered by the front roller. Such changes always affect the weight of the delivery, per unit of length, in inverse terms.

The draft, as contained in the present roller gearing (Fig. 22), is as follows:—

Between the first and second rollers $= \dfrac{25 \times \frac{7}{8}}{18 \times 1''} = 1{\cdot}216$

,, second and third ,, $= \dfrac{18 \times 56 \times 90 \times \frac{7}{8}}{25 \times 40 \times 28 \times 1''} = 2{\cdot}84$

,, first and third ,, $= \dfrac{56 \times 90 \times 1''}{40 \times 28 \times 1''} = 4{\cdot}5$

Any change in those wheels would have effects corresponding with those noted in respect of the rollers in drawing frames.

The count obtained by the above attenuation in the rollers would be 4·5 times finer than the feed.

The feed in the slubber generally consists of one end per rove delivered, whilst in the intermediate, rover, and jack it always comprises two ends. Thus, in the case where 0·2 is the count of the feed in a slubber having 4·5 of a draft, $0{\cdot}2 \times 4{\cdot}5 = 0{\cdot}9$ would be the count delivered. An intermediate with 4·5 draft, treating slubbing of 0·9 count, would produce $\dfrac{0{\cdot}9}{2} \times 4{\cdot}5 = 2{\cdot}025$ count. A roving frame, with a like draft, using that count of intermediate rove, would produce $\dfrac{2{\cdot}025}{2} \times 4{\cdot}5 = 4{\cdot}556$ count.

A change in any of the wheels connecting the first or back with the front roller would have the following effect :—

If a driver, the count and the draft would be altered in the inverse, and the weight in the direct proportion.

If a driven, the count and the draft would be altered in the direct, and the weight in the inverse proportion.

Altering the Draft.—The following would be the draft and count with the draft wheels, as stated below, when the other roller gear is as given in Fig. 22 ; the count of the rove fed being 2·025.

If the pinion was altered to	60	50	45	36	30
The draft would become	3·0	3·6	4·0	5·0	6·0
The count would become	3·03	3·64	4·05	5·05	6·06

If the back-roller wheel was altered to	51	48	42	60	65	70
The draft would become	4·1	3·86	3·37	4·82	5·22	5·62

If the front roller wheel was altered to	26	24	22	20
The draft would become	4·85	5·25	5·73	6·3

If the crown wheel was altered to	130	120	110	100	80	70
The draft would become	6·5	6·0	5·5	5	4	3·5

NOTE.—The front roller and pinion wheels (28 and 56) are drivers.
The crown and back roller wheels (90 and 56) are driven.
The ratio of the crown to the front roller wheel.
The ratio of the pinion to the back roller wheel.
That any pairs of these wheels possessing these ratios will produce the same results.

EXAMPLES AND EXERCISES IN CHANGING THE DRAFT.

Example.	Weight or count of the rove or sliver fed.	Number of ends doubled.	Weight or count delivered.	Draft.	Draft gear. Diameters of F.R. and Back R. alike.			
					F.R.W.	C.W.	P.W.	B.R.W.
1	2	2	5	?	25	100	?	50
2	?	2	5	6	25	100	40	?
3	2	2	?	5·5	25	100	?	60

Working 1.—Draft $= \frac{5 \times 2}{2} = 5$; $\frac{50}{\text{P.W.}} \times \frac{100}{25} = 5$ $\therefore$ P.W. $= \frac{50}{5} \times \frac{100}{25} = 40$

Working 2.—Count fed $= \frac{5 \times 2}{6} = 1\frac{2}{3}$; $\frac{\text{B.R.W.}}{40} \times \frac{100}{25} = 6$

$\therefore$ B.R.W. $= \frac{40 \times 25 \times 6}{100} = 60$

Working 3.—Count delivered $= \frac{2}{2} \times 5{\cdot}5 = 5{\cdot}5$; $\frac{60 \times 100}{? \times 25} = 5{\cdot}5$

$$\therefore \text{P.W.} = \frac{60 \times 100}{5{\cdot}5 \times 25} = 43{\cdot}6$$

Exercise.	Weight or count of each rove or sliver fed.	Number of ends doubled.	Weight or count delivered.	Draft.	Draft gear. Diameters of F.R. and Back R a ike.				
					F.R.W.	C.W.	P.W.	B.R.W.	
1	2·775	2	?	?	28	90	40	56	
2	”	”	6·0	?	28	90	40	?	
3	”	”	Ditto	—	—	—	Ratio	?	
4	?	2	6·0	?	28	90	40	56	
5	30 yds. = 125 grs.	2	30 yds. = 50 grs.	?	28	90	Ratio	?	
6	—	”	5·2	?	”	”	?	56	Change to the latter of these conditions.
	—	”	5·0	?	”	”	40	56	
7	30 yds. = 125 grs.	”	6	—	—	—	50	—	From these conditions change to the latter.
	30 yds. = 135 grs.	”	5	?	—	—	?	—	
8	30 yds. = 125 grs.	”	6	?	28	90	?	60	From these conditions change to the latter.
	30 yds. = 135 grs.	”	6	?	28	90	?	60	
9	0·18	1	?	4	25	100	?	?	
10	0·17	1	?	4	25	?	50	60	
11	?	1	0·765	?	25	100	56	63	
12	0·2	1	0·96	?	25	100	50	?	

The following must always be known to enable the gearing to be adapted for the production of any specific count :—

(1) The count required.

(2) The count of the feed.

(3) The characteristics of the cotton.

(1) and (2) determine the draft.

(1) and (3) determine the twist.

The Rate of the Winding and Spacing of the Coils cannot be accurately ascertained by calculation on account of the dissimilarity in the size of rovings. The winding must be regulated by adjusting the position of the strap on the cones. The rate of the vertical movement of the bobbin rail must be adjusted to space the coils without tendency to override or apertures Generally about six coils of count one can be laid per inch This is useful as a basis in the absence of other data.

The twist per inch obtained by the gearing as per Fig. 22 $= 3{\cdot}0\dot{3}$ inches. According to data on p. 112, the twisting would be adapted for—

(*a*) If Sea Islands cotton $\left(\frac{3{\cdot}0\dot{3}}{1}\right)^2 = 9{\cdot}1$

(*b*) If Egyptian cotton $\left(\frac{3{\cdot}0\dot{3}}{1 \text{ to } 1{\cdot}2}\right)^2 = 9{\cdot}1 \text{ to } 6{\cdot}4$

(*c*) If Brazilian cotton $\left(\frac{3{\cdot}0\dot{3}}{1{\cdot}2}\right)^2 = 6{\cdot}4$

(*d*) If American cotton $\left(\frac{3{\cdot}0\dot{3}}{1{\cdot}2 \text{ to } 1{\cdot}3}\right)^2 = 6{\cdot}4 \text{ to } 5{\cdot}4$

(*e*) If Indian cotton $\left(\frac{3{\cdot}0\dot{3}}{1{\cdot}4 \text{ to } 1{\cdot}5}\right)^2 = 4{\cdot}7 \text{ to } 4{\cdot}1$

Thus five frames employed as above stated with the draft 4·5: the count of the feed and that in the creel would be respectively—

(*a*) $\frac{9{\cdot}1}{4{\cdot}5} = 2{\cdot}02 \quad \therefore 2{\cdot}02 \times 2 = 4{\cdot}04$

(*b*) $\frac{6{\cdot}4}{4{\cdot}5} = 1{\cdot}42 \quad \therefore 1{\cdot}42 \times 2 = 2{\cdot}84$

(*c*) $\frac{6{\cdot}4}{4{\cdot}5} = 1{\cdot}42 \quad \therefore 1{\cdot}42 \times 2 = 2{\cdot}84$

(*d*) $\frac{5{\cdot}4}{4{\cdot}5} = 1{\cdot}2 \quad \therefore 1{\cdot}2 \times 2 = 2{\cdot}4$

(*e*) $\frac{4{\cdot}7}{4{\cdot}5} = 1{\cdot}04 \quad \therefore 1{\cdot}04 \times 2 = 2{\cdot}08$

or, $\frac{4{\cdot}1}{4{\cdot}5} = 0{\cdot}91 \quad \therefore 0{\cdot}91 \times 2 = 1{\cdot}82$

A change in the pinion wheel would have the inverse effect upon the counts produced, and would influence the weight per unit of length in the direct proportion. Therefore a 30-draft pinion instead of 40 would produce the following counts, assuming the feed as in the above instances :—

(*a*) $$\frac{9{\cdot}1 \times 40}{30} = 12{\cdot}1$$

(*b*) $$\frac{6{\cdot}4 \times 40}{30} = 8\ 5$$

(*c*) $$\frac{6{\cdot}4 \times 40}{30} = 8{\cdot}5$$

(*d*) $$\frac{5{\cdot}4 \times 40}{30} = 7{\cdot}2$$

(*e*) $$\frac{4{\cdot}7 \times 40}{30} = 6{\cdot}27$$

A change in the back roller wheel would have the inverse effect to that of the pinion.

Whenever the count is changed, it would become necessary to re-adjust the twist per inch to $\sqrt{\text{count}} \times$ twist constant. The rate of the front roller would need altering in the proportion inverse to the twists. Thus, assuming the twist wheel in each of the frames, referred to in the last-mentioned examples, 39, the changes in count would necessitate the following alterations in the twist wheel :—

For (*a*) $$\frac{39 \times \sqrt{9{\cdot}1}}{\sqrt{12{\cdot}1}}$$

NOTE.—The twists are in the direct proportion of the square root of the counts, and hence the latter may substitute the former.

For (*b*) $$\frac{39 \times \sqrt{6{\cdot}4}}{\sqrt{8{\cdot}5}}$$

For (*c*) $$\frac{39 \times \sqrt{6{\cdot}4}}{\sqrt{8{\cdot}5}}$$

For (*d*) $$\frac{39 \times \sqrt{7{\cdot}2}}{\sqrt{5{\cdot}4}}$$

For (*e*) $$\frac{39 \times \sqrt{4{\cdot}7}}{\sqrt{6{\cdot}27}}$$

Assuming x the size of the ratchet wheel and y that of the lifter change wheel, the following procedure would obtain x and

y adapted for the above-named changes: because the size of the rove and yarns of a given class are found to vary inversely as the square root of their counts when other conditions are equal.

$$\text{For } (a) \ \frac{x\sqrt{12 \cdot 1}}{\sqrt{9 \cdot 1}} \text{ and } \frac{y\sqrt{9 \cdot 1}}{\sqrt{12 \cdot 1}}$$

$$(b) \ \frac{x\sqrt{8 \cdot 5}}{\sqrt{6 \cdot 4}} \text{ and } \frac{y\sqrt{8 \cdot 5}}{\sqrt{6 \cdot 4}}$$

NOTE.—x must contain more teeth, because these wheels are made a standard size by each maker; they differ in the pitch of their teeth only.

x controls the movement of the cone strap at the completion of each layer on the bobbin. It is this movement that obtains the retardation in the speed, of the bottom cone, necessary to secure perfect tension in winding. The extent of the movement of the cone strap must be in accordance with the proportional increase resulting from each layer laid upon the bobbin. Hence, the number of teeth contained in these wheels must be altered relatively, inverse to the square root of the counts, which sum represents the thickness of the roves wound.

y must contain fewer teeth for smaller roves in the direct proportion of their diameter, these are, for the same kind of cotton, relatively inverse to the square root of their counts; because a smaller rove requires less space, and hence slower speed of the bobbin rail, of which train y is a driver. If it was preferable to alter a driven wheel in that train, then a wheel containing more, instead of less, teeth would be necessary.

EXERCISES IN MISCELLANEOUS FLY FRAME CALCULATIONS.

1. In a roving frame the twist wheel has 30 teeth, and drives by a carrier the wheel in the middle of the top cone shaft, containing 40 teeth. On the end of the latter shaft a 48 gears with one on the front roller containing 130 teeth. The front roller is $1\frac{1}{8}$ inches in diameter. The spindle bevel wheel has 30 teeth, and that driving it has 55; a wheel of 40 teeth on this latter shaft is driven from the frame shaft by one of the same size. Find the twist per inch.

2. Ascertain the twist per inch, the twist constant, the production in hanks

and ounces per spindle per 10 hours, under the following conditions in a roving frame. Revolutions per minute: spindle, 1150; F.R. 120: diameter, $1\frac{1}{8}$ inch; draft, 5, count fed: two ends of 3·5 hank intermediate rove; loss of time, 8 per cent.

3. A roving frame is required to produce 9-hank rove containing twist equal to $\sqrt{\text{count}} \times 1·4$, and the spindles making 1200 revolutions per minute; the diameter of the front roller is $1\frac{1}{4}$ inch. At what rate must the roller be driven?

4. At what rate must the bobbins rotate to obtain good winding during the first layer under the following conditions: Gear from the front roller to the frame shaft, $\frac{130}{48}$, $\frac{48}{35}$, that from the frame shaft to the spindles, $\frac{40}{42}$, $\frac{55}{30}$; diameters, of front roller, $1\frac{1}{8}$ inch, of the bobbin, $1\frac{1}{2}$ inch; revolutions per minute of the frame shaft, 300?

5. A fly frame making a 6-hank rove has the following change wheels: Draft pinion, 42; twist, 36; ratchet, 40; lifter (driver), 26. What sizes of these wheels respectively would be required for a 5-hank?

Ans. 50, 39, 37, 29.

6. The spindles in a slubber making a 0·75-hank rove are observed to rotate 4·5 times per 1 of the front roller, which is $1\frac{1}{4}$ inch in diameter: the change wheels are—twist, 40; ratchet, 19; lifter, 26; draft pinion, 42: and the spindles are known to make 550 revolutions per minute. Ascertain: (*a*) the present twist per inch; (*b*) the twist per inch suitable for 0·58-hank, and also the change wheels required; (*c*) the rate of production in both cases in hanks and ounces per spindle per 10 hours, assuming 15 per cent. represents the loss of time.

Ans. 1·15; 1·01, 49, or $\frac{15}{16}$, 32, 63; 8·1, 173; 9·93, 358.

7. What lifter wheels would be most suitable in using the same cotton for 1·0 and for 0·5 hank, if it was known that 6 coils per inch was the most satisfactory spacing for 1 hank and a 28 lifter wheel (driver) gave 7 coils per inch?

Ans. 24; 17.

8. What sizes of ratchet wheels would be most suitable in using the same cotton for 1·0 and for 0·5 hank, if it was known that a 14 was most suitable for 0·68 hank?

Ans. 17; 12.

9. The spindles in a roving frame producing 7-hank roving make 1120, and the front roller 100, revolutions per minute; the latter is $1\frac{1}{8}$ inch in diameter. What twist per inch should the rove contain? Give the twist constant and the hanks produced in 10 hours' uninterrupted working.

Ans. 3·17; 1·2; 7·02.

10. The draft in the rollers of a roving frame is 6 and the intermediate roving is 2·6 hanks, and two of these are doubled: what count of rove will be made? If the count, ascertained, has to be changed to 6ˢ, and the draft wheels and rollers are F.R.W. 20, C.W. 80, P.W. 40, B.R.W. 60; diameters, F.R. $1\frac{1}{8}$ inch, B.R. $1\frac{1}{8}$ inch, which of these wheels would you alter, and to what extent?

Ans. 7·8—P.W. to 52.

11. A roving frame is making 7·8 hank-roving with the following wheels: Draft pinion, 40; twist wheel, 38; ratchet, 46; lifter, 28. What wheels would be needed for 6? What effect would these changes have upon the length and weight produced?

Ans. 52, 43, 40, 32 increase in length, 38 to 43; increase in weight, 6 to 8·9.

Exercise No.		Cotton and count.	Twist.		Roller gear.			Winding.	Spacing lifter wheel.		Count fed.	Twist constant.
			Per inch.	Wheel.	Draft.	Pinion.	B.R.W.	Ratchet.	Driver.	Driven.	Two ends up each.	
12	Present	American 6·4	3·0$\dot{3}$	39	4·5	45	56	40	14	56	2·84	1·28
	Required	„ 8	?	?	?	?	?	?	?	?	„	„
13	Present	Egyptian 10	?	?	5	?	?	52	14	42	?	1·1
	Required	„ 12	4·5	?	?	?	?	?	„	?	5	?
14	Present	American 4·2	?	?	?	?	?	33	17	56	1·4	1·3
	Required	„ 3	?	?	?	?	?	?	?	—	„	„
15.	Present	Indian 2½	?	?	?	?	56	20	?	56	1·0	1·4
	Required	„ 2¼	?	?	?	?	56	?	?	„	„	„
16	Present	Egyptian 16	4·8	36	5	60	60	56	—	48	?	?
	Required	„ 20	?	?	?	?	60	?	—	?	6⅓	?
17	Present	Indian 3	?	50	?	50	54	24	18	42	1·4	1·4
	Required	„ 4	?	?	5	?	54	?	?	?	„	1·5

Winding in Fly Frames is obtained by the Bobbin.—Winding in these frames is due to the bobbin rotating at a slower or quicker rate than the spindles. In the former case the "flyer leads" and in the latter the "bobbin leads." The rates of rotation of the spindles and rollers being constant, winding is obtained by that of the bobbin differing from the former of these to an extent sufficient to wind the amount delivered by the rollers. Generally, the range in the size of the bobbins is from 1⅛ inch upward, empty, to below 6 inches when full. It is not often that full bobbins exceed more than four times their size when empty.

Winding is arrested, in these machines, when the bobbins assume the same rate of rotation as the spindle or flyer. Thus if the latter exceeds the former, or *vice versâ*, the difference represents the coils wound. However large the bobbin becomes —when winding is required—the rate of rotation must, as its size develops, approach that of the spindle, but never attain the same speed equal to it. Therefore, if the bobbin leads and the spindle makes 1000 revolutions per minute, however large the bobbin may become, its rate must be something more than 1000. In the case of the bobbin being 1½ inches in diameter, empty, and 6 inches diameter when full, and the length wound equal to 120 times the circumference of the former size, then the bobbin

must revolve at the rate of $1000 + \frac{120 \times 1\frac{1}{2}}{6} = 1030$ revolutions when full, as against $1000 + 120$ empty.

The Use of Cone Drums.—Cone drums are used to give the necessary variations in the speed of the bobbins. Their work consists of contributing toward the driving of the bobbin an amount sufficient only to ensure winding at the desired tension, the remainder an amount which is always equal to the rate of the spindle being obtained from a fixed contributor.

The Use of Differentials.—Differentials admit of the transmission of the motion from the two above-named sources with the most satisfactory results. A simple way of calculating the motion transmitted through the differential gear is as follows:—

Let n denote the motion issuing from it; m, that portion of n derived from the fixed contributor; a, that portion of n derived from the variable contributor; M and A, the rates of those parts of the differential responsible for m and a

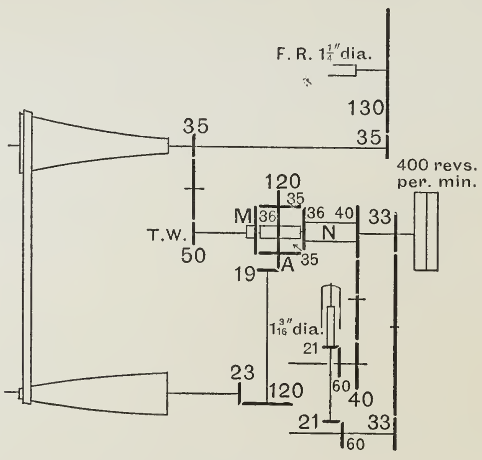


Fig. 23.

respectively; t, the values of the respective connecting trains connecting M and A with n—

then n consists of $m \pm a$

Applying this to the Holdsworth differential gear (Fig. 23):—
When M is at rest and motion is imparted to A,

revolutions of $n = \text{A} \pm \text{A}t$ (in the same direction).

When A is at rest and M is moved, then—

$$\text{revolutions of } n = \mathrm{M}t$$

in the opposite direction to M. Therefore when A and M rotate in the same direction,

$$\text{revolutions of } n = \mathrm{A} \pm \mathrm{A}t - \mathrm{M}t$$

and when A and M revolve in opposite directions,

$$\text{revolutions of } n = \mathrm{A} \pm \mathrm{A}t + \mathrm{M}t$$

Thus, if M makes 300 and A 60 revolutions, both in the same direction, and the value of t is 1, then, by using $n = a - m$, or its equivalent, $n = \mathrm{A} + \mathrm{A}t - \mathrm{M}$—

$$n = 60 + 60 \times 1 - 300 \times 1 = 120 - 300 = -180 \text{ revolutions}$$

$\therefore n = 180$ revolutions in the direction opposite to A

Should A and M move in opposite directions at the rates of 60 and 300 revolutions respectively, then—

$$n = a + m$$

or, $n = \mathrm{A} + \mathrm{A}t + \mathrm{M}t$

$\therefore n = 60 + 60 \times 1 + 300 \times 1 = 420$ in the same direction as A

Thus, the fractional movement of n, due to a, is, in the latter instance, 120, and that due to m is 300, so that the plus 60 has become plus 120, and the minus 300 has changed to plus that sum.

Examples in Calculating the Length Wound upon the Bobbin with the Principal Types of Differentials.

The particulars contained in Fig. 23 are those existing in a roving frame in working condition. The particulars not given in the figure are—The diameter of top cone, in the part on which the centre of the cone strap rests, is $5\frac{11}{16}$ inches, and the diameter of the bottom cone, also opposite the centre of the strap, $3\frac{7}{16}$ inches; the diameters of the empty bobbin $1\frac{3}{16}$ inch, and that of the front roller $1\frac{1}{4}$ inch. Under these conditions the

$$\text{revolutions of the spindle per minute} = \frac{400 \times 33 \times 60}{33 \times 21} = 1142\frac{6}{7}$$

and the revolutions of the bobbin per minute, when the bottom cone is stopped, or when the twist wheel is 0—

$$= \mathrm{M}t \times \frac{40 \times 60}{40 \times 21}$$

Since the two wheels in the sun wheel are carriers, and the wheel on the frame shaft driving them is 36 and that driven by this train is also a 36, t therefore equals $\frac{36}{36} = 1$. Hence the revolutions of the bobbin per minute $= 400 \times 1 \times \dfrac{40 \times 60}{40 \times 21} = 1142\frac{6}{7}$ or the same speed and in the same direction as the spindle.

The revolutions of the bobbin per minute, when the bottom cone is working and the twist wheel is 50, are

$$= (\mathrm{A} + \mathrm{A}t \pm \mathrm{M}t)\frac{40 \times 60}{40 \times 21}$$

or—

$$\left[\left(\frac{400 \times 50 \times 91 \times 23 \times 19}{1 \times 35 \times 55 \times 120 \times 130} + \frac{400 \times 50 \times 91 \times 23 \times 19}{1 \times 35 \times 55 \times 120 \times 130}t\right) \pm 400t\right] \times \frac{40 \times 60}{40 \times 21}$$

Here $t = 1$, and the sun wheel moves in the opposite direction to M, and, therefore, the sign is +, hence

$$\left(2 \times \frac{400 \times 50 \times 91 \times 23 \times 19}{1 \times 35 \times 55 \times 120 \times 120} + 400\right) \times \frac{40 \times 60}{40 \times 21}$$

$$= \text{revolutions of bobbin per minute}$$

$$= \left(57 \times \frac{76}{198} + 400\right) \times \frac{60}{21} = 1306{\cdot}8$$

Therefore, the revolutions of the bobbins in excess of the spindles

$$= 1306{\cdot}8 - 1142{\cdot}8 = 164$$

The length of rove wound upon the bobbin per minute, neglecting the facts that the rove is wound spirally, and also that the actual winding radius is greater than the radius of the bare bobbin, is

$$= 164 \times \frac{19'' \times 22}{16 \times 7} = 612 \text{ inches per minute}$$

the revolutions per minute of the front roller being $\frac{400 \times 50 \times 35}{35 \times 130}$, and the length delivered by it in that time—

$$= \frac{400 \times 50 \times 35 \times 5'' \times 22}{1 \times 35 \times 130 \times 4 \times 7} = 605 \text{ inches}$$

Upon this basis the bobbin is shown to wind 7 inches more than the actual length delivered by the front roller. When the amount due to contraction in the roving, by reason of the twist inserted in it, is added to the difference due to the spiral disposal of the coils, and also to the difference between the actual radius of these coils and that of the bobbin, the tension of winding must be considerably more than is represented in the calculation.

The particulars contained in Fig. 24 are of a roving frame,

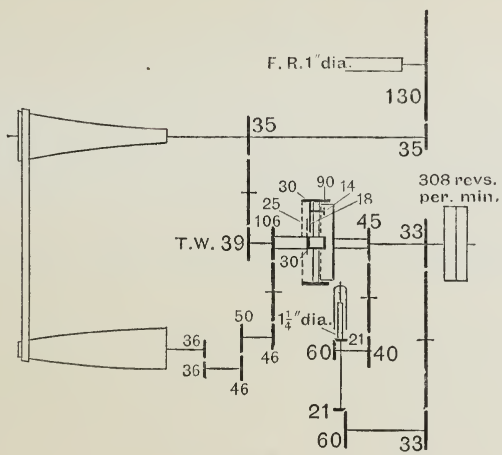


Fig. 24.

the differential in this instance being of the Curtis and Rhodes type.

Proceeding to deal as with Fig. 23—

$$n = m \pm a$$

When M is at rest it will be seen, upon examination of this differential, that, if the bottom cone is rotated,

$$n = a, \text{ or } At$$

and in the same direction.

When A is at rest and M is rotated,

$$n = m, \text{ or } \mathrm{M} - \mathrm{M}t$$

and when M and A revolve in the same direction,

$$n = m + a, \text{ or } \mathrm{M} - \mathrm{M}t + \mathrm{A}t$$

Therefore when M and A revolve in opposite directions,

$$n = m - a, \text{ or } \mathrm{M} - \mathrm{M}t - \mathrm{A}t$$

The value of t in each of the above instances is the same, being—

$$\frac{30 \times 18 \times 14}{25 \times 30 \times 90}$$

According to the particulars contained in the figure, it will be seen that when A is at rest,

$$n = 308 - 308t$$

$$\therefore n = 308 - \frac{308 \times 30 \times 18 \times 14}{25 \times 30 \times 90}$$

The portion of n denoted by a, when the diameters of the cones at the points opposite the centre of the strap are—top, $5\frac{3}{4}$, bottom $3\frac{1}{2}$ inches; equals

$$\frac{308 \times 39 \times 5\frac{3}{4} \times 36 \times 46 \times 46 \times 30 \times 18 \times 14}{35 \times 3\frac{1}{2} \times 36 \times 50 \times 106 \times 25 \times 30 \times 90}$$

M and A are indicated in the figure as working in the same direction, the flyer and the bobbin are also revolving in the same direction, the latter leading; the connecting sign between m and a must therefore be plus—

$$\therefore n = \left(308 - \frac{308 \times 30 \times 18 \times 14}{25 \times 30 \times 90}\right)$$

$$+ \left(\frac{308 \times 39 \times 5\frac{3}{4} \times 36 \times 46 \times 46 \times 35 \times 18 \times 14}{35 \times 3\frac{1}{2} \times 36 \times 50 \times 106 \times 25 \times 30 \times 90}\right)$$

Under these conditions the revolutions of the bobbin per minute will equal—

$$n \times \frac{45 \times 60}{40 \times 21}$$

or—

$$\left[\left(308 - \frac{308 \times 30 \times 18 \times 14}{25 \times 30 \times 90}\right) + \left(\frac{308 \times 39 \times 5\frac{3}{4} \times 36 \times 46 \times 46 \times 35 \times 18 \times 14}{35 \times 3\frac{1}{2} \times 36 \times 50 \times 106 \times 25 \times 30 \times 90}\right)\right] \times \frac{45 \times 60}{40 \times 21} = 966{\cdot}37$$

Of this sum the exact amount due to the cones, signified by a, is—

$$\left(\frac{308 \times 39 \times 5\frac{3}{4} \times 36 \times 46 \times 46 \times 35 \times 18 \times 14}{35 \times 3\frac{1}{2} \times 36 \times 50 \times 106 \times 25 \times 30 \times 90}\right) \times \frac{45 \times 60}{40 \times 21}$$

$= 87{\cdot}27$ revolutions per minute

The amount contributed directly from the shaft through the differential, and signified by m, is—

$$\left(\frac{308}{1} - \frac{308 \times 30 \times 18 \times 14}{25 \times 30 \times 90}\right) \times \frac{45 \times 60}{40 \times 21} = 879{\cdot}1$$

The revolutions which the spindles would make per minute are

$$= 308 \times \frac{33 \times 60}{33 \times 21} = 880$$

in the same direction as the bobbin. Thus, the bobbin leads the flyer to the extent of

$$966{\cdot}37 - 880 = 86{\cdot}37 \text{ revs.}$$

This represents the amount of rove wound, which should of course be approximately equal to that delivered by the rollers. The revolutions of the front roller in the same time are

$$= 308 \times \frac{39 \times 35}{35 \times 130} = 92{\cdot}4$$

Therefore the length delivered per minute is

$$= 92{\cdot}4 \times \tfrac{22}{7} = 290{\cdot}4$$

The amount which the bobbin would wind, assuming the material wound was $\frac{5}{8}$ inch radius from the centre of the bobbin, equals

$$86{\cdot}37 \times 1\tfrac{1}{4} \times \tfrac{22}{7} = 339{\cdot}71 \text{ inches}$$

Under these conditions the 290·4 inches of rove delivered by the front roller per minute would be stretched to 339·71, or to the extent of

$$339{\cdot}71 - 290{\cdot}4 = 49{\cdot}31$$

this being 17 per cent.

A noticeable feature in respect of the gearing in this figure is that the bobbin is not driven at the same rate as the spindle when the cone drum ceases to be a contributor. This makes the correct adjustment of winding impossible. Thus, when the cone is stopped, the revolution of the bobbin per one of the spindle is—

$$\left[\frac{21 \times 33}{60 \times 33} - \left(\frac{21 \times 33 \times 30 \times 18 \times 14}{60 \times 33 \times 25 \times 30 \times 90}\right)\right] \times \frac{45 \times 60}{40 \times 21}$$

$$= \left[\frac{21}{60} - \frac{49}{1250}\right] \times \frac{45 \times 60}{40 \times 21} = \frac{26250 - 2940}{75000} \times \frac{45 \times 60}{40 \times 21}$$

$$= \frac{23310 \times 45 \times 60}{75000 \times 40 \times 21} = \frac{999}{1000} = 0{\cdot}999$$

The bobbin moving slower to the extent of 0·001 per revolution of the spindle, and thus, whilst the cone is stopped, if the spindle makes 880 revolutions, the bobbin would make

$$880 \times 0{\cdot}999 = 879{\cdot}12 \text{ revolutions}$$

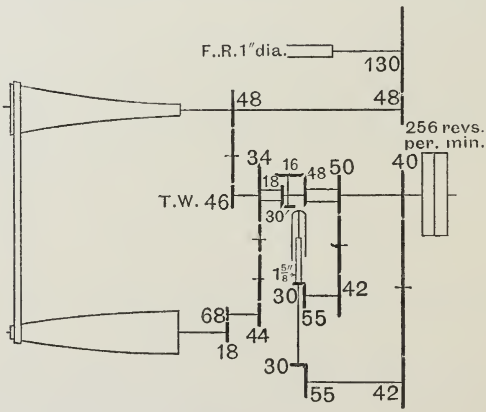


Fig. 25.

The particulars given in Fig. 25 are taken from an·

intermediate frame. The differential in this case is of the Tweedale type. Dealing with this as with the previous examples—

$$n = m \pm a$$

When M is at rest and the bottom cone is actuated,

$$n = a, \text{ or } \mathrm{A}t$$

and in the same direction. When A is at rest,

$$n = m, \text{ or } \mathrm{M} - \mathrm{M}t$$

When M and A revolve in the same direction,

$$n = m + a, \text{ or } \mathrm{M} - \mathrm{M}t + \mathrm{A}t$$

When M and A revolve in opposite directions,

$$n = m - a, \text{ or } \mathrm{M} - \mathrm{M}t - \mathrm{A}t$$

The value of t in this case is—

$$\frac{18 \times 16}{30 \times 48}$$

Taking the speed of the frame shaft at $256\frac{2}{3}$ revolutions per minute with the bottom cone at rest—

$$n = 256\tfrac{2}{3} - \frac{256\frac{2}{3} \times 18 \times 16}{30 \times 48}$$

This being the portion contributed to n, from source m, when M and A are both in action together.

That portion of n contributed from source a, when the diameters of the top and bottom cones—at the points opposite the centre of the strap during the winding of the first layer—are $5\frac{7}{8}$ inches and $3\frac{5}{8}$ inches respectively, will be—

$$256\tfrac{2}{3} \times \frac{46 \times 5\frac{7}{8} \times 18 \times 44 \times 18 \times 16}{48 \times 3\frac{5}{8} \times 68 \times 34 \times 30 \times 48}$$

therefore when the M and A are working together—

$$n = \left(256\tfrac{2}{3} - \frac{256\frac{2}{3} \times 18 \times 16}{30 \times 48}\right) + \left(256\tfrac{2}{3} \times \frac{46 \times 5\frac{7}{8} \times 18 \times 44 \times 18 \times 16}{48 \times 3\frac{5}{8} \times 68 \times 34 \times 30 \times 48}\right)$$

the revolutions of the bobbins being—

$$n \times \frac{50 \times 55}{42 \times 30}$$

The revolutions of the bobbin per minute are therefore—

$$\left[\left(256\tfrac{2}{3} - \frac{256\frac{2}{3} \times 18 \times 16}{30 \times 48}\right) + \left(256\tfrac{2}{3} \times \frac{46 \times 5\frac{7}{8} \times 18 \times 44 \times 18 \times 16}{48 \times 3\frac{5}{8} \times 68 \times 34 \times 30 \times 48}\right)\right]$$

$$\times \frac{50 \times 55}{42 \times 30} = \left[(256\cdot\dot{6} - 51\cdot\dot{3}) + 27\cdot3\right] \times \frac{50 \times 55}{42 \times 30}$$

$$= (205\cdot\dot{3} + 27\cdot3) \times \frac{50 \times 55}{42 \times 30} = 508$$

The revolutions per minute which the bobbins would make if the bottom cone was stopped would be—

$$(256\cdot\dot{6} - 51\cdot\dot{3}) \times \frac{50 \times 55}{42 \times 30} = 448\cdot\dot{1}4\dot{8}$$

The revolutions of the spindles per minute would be—

$$256\tfrac{2}{3} \times \frac{40 \times 55}{42 \times 30} = 448\cdot\dot{1}4\dot{8}$$

The revolution of the bobbin per 1 revolution of the spindle, according to the above working, is therefore—

$$\frac{448\cdot\dot{1}4\dot{8}}{448\cdot\dot{1}4\dot{8}} = 1$$

Working directly from the spindle to the bobbin, this last result is proved as follows:—

$$\left[\frac{30 \times 42}{55 \times 40} - \left(\frac{30 \times 42 \times 18 \times 16}{55 \times 40 \times 30 \times 48}\right)\right] \times \frac{50 \times 55}{42 \times 30}$$

= revolutions of bobbin per 1 of spindle

$$= \left[\frac{315}{550} - \frac{63}{550}\right] \times \frac{50 \times 55}{42 \times 30} = \frac{252 \times 50 \times 55}{550 \times 42 \times 30}$$

$= \frac{1}{1} =$ 1 revolution of bobbin per 1 of spindle

The revolutions per minute of the front roller are—

$$256\tfrac{2}{3} \times \frac{46 \times 48}{48 \times 130}$$

The length of rove delivered by the front roller per minute—

$$256\tfrac{2}{3} \times \frac{46 \times 48 \times 1'' \times 22}{48 \times 130 \times 1 \times 7} = 285 \text{ inches}$$

The number of coils of rove wound per minute, being the difference in the revolutions as compared with the spindle—

$$= 508 - 448\cdot\dot{1}4\dot{8} = 59\cdot85 \text{ nearly}$$

The length actually wound on the bobbin, assuming the radius of the coils $\frac{1\frac{5}{8}''}{2}$, $1\frac{5}{8}$ inches being the diameter of the bare bobbin, would be—

$$= 59\cdot85 \times \frac{13 \times 22}{8 \times 7} = 305\cdot6 \text{ inches}$$

Thus the length of the rove wound on the bobbin exceeds that delivered by the roller to the extent of $305\cdot6 - 285$, or $20\cdot6$ inches, equal to $7\cdot2$ per cent.

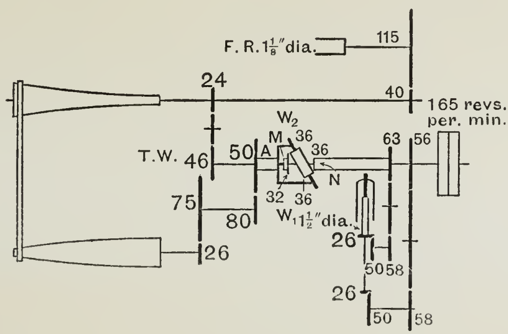


FIG. 26.

In Fig. 26 the differential is that known as the Fallows motion. The particulars herewith given are of a slubbing frame. This differential differs considerably from the usual types, and an explanation of its action is deemed advisable.

The right extreme of the portion marked A consists of a cam, the face of this bears against the side of a disc formed upon the rim of a double wheel. W_1 and W_2 denote the left and right-hand sides of this disc wheel. The teeth are of special design, and the wheel is mounted, loose, on a spherical bearing. This spherical bearing is secured to the driving shaft. This form of bearing admits of a portion of W_1 being in gear at a point with M, and a portion of W_2 also in gear at a point with N, but on the opposite side of the axis. Thus, the double wheel gears and

works in an oblique position, and this is maintained by the pressure of the cam against the sides of the disc. Under these conditions W_1 and W_2 act as a compound wheel toward motion passing from M to N. Under these conditions the value of the train would be—

$$= \frac{M}{W_1} \times \frac{W_2}{N}$$

The effect of the movement of A, when M is at rest, is that the cam would compel the gearing points of W_1 and W_2 to circulate, the teeth of the former entering and emerging from the teeth contained in M as A revolves; therefore if W_1 contains the same number of teeth as M, no circumferential motion of W_1 or W_2 could accrue. This reasoning applies in a similar manner to W_2 and N. Should M and W_1 contain different numbers of teeth, then circumferential motion will be imparted to W_1 and W_2 in the direction opposite to that of A, when W_1 contains less, and in the same direction when W_1 has more, teeth than W_2. Thus, the movement of W_1 would be $W_1 - M$, in teeth per revolution of A, and its rotary movement would be—

$$\frac{W_1 - M}{W_1}$$

The movement in teeth made by W_2, in the same time, would be—

$$\frac{W_1 - M}{W_1} \times \frac{W_2}{1}$$

and, therefore, if N contained the same number of teeth as W_2, the movement of N would be the same as W_2.

If the number of teeth in W_2 and N were not alike, the movement would be further affected by reason of the cam A causing all the teeth in W_2 to enter, and emerge from, as many of those in N as are contained in W_2. Thus, the action in this case must be, when M is at rest and A makes one revolution—

$$= \frac{W_1 - M}{W_1} \times \frac{W_2}{N} + \frac{N - W_2}{N}$$

In this differential *t* has two values. In respect of the motion from M its value is—

$$\frac{M}{W} \times \frac{W_2}{N}$$

Let this be termed t_1. When the motion is from A its value is—

$$\frac{W_1 - M}{W_1} \times \frac{W_2}{N} + \frac{N - W_2}{N}$$

Let this latter be denoted by t_2.

It will now be possible to proceed to deal with this in the same manner as with previous examples—

$$n = m \pm a$$

under all conditions.

Therefore when A is at rest—

$$n = \mathrm{M}t_1$$

in the same direction.

When M is at rest—

$$n = \mathrm{A}t_2$$

the resultant direction depending on the differences in the number of teeth contained in the wheels M, W_1, W_2, and N. This will be indicated by the sign being either plus or minus.

When M and A revolve in the same direction together—

$$n = \mathrm{M}t_1 + \mathrm{A}t_2$$

Taking the particulars of the gear as contained in Fig. 26, and the diameters of the cones at the points opposite the middle of the cone strap, when the first layer is being wound, as follows:—top $7\frac{1}{8}$ inches, bottom $3\frac{3}{8}$ inches, and that of the bare bobbin $1\frac{1}{2}$ inch; then: the revolutions of the bobbin per minute when the twist wheel is 0, or when the bottom cone is not engaged, would be, according to the formula—

$$\frac{165 \times 32 \times 36 \times 63 \times 50}{1 \times 36 \times 36 \times 58 \times 26} = 306{\cdot}366$$

The revolution of the bobbin per minute with a 50 twist wheel, assuming M to be at rest whilst A is in motion—

$$= \left[\frac{165 \times 46 \times 7\frac{1}{8} \times 26 \times 80}{1 \times 24 \times 3\frac{3}{8} \times 75 \times 50}\left(\frac{36 - 32}{36} \times \frac{36}{36} + \frac{36 - 36}{36}\right)\right] \times \frac{63 \times 50}{58 \times 26}$$

$$= \frac{165 \times 46 \times 57 \times 26 \times 8 \times 4 \times 63 \times 50}{1 \times 24 \times 27 \times 75 \times 5 \times 36 \times 58 \times 26} = 85{\cdot}95$$

Therefore the revolutions per minute of the bobbin during the winding of the first layer would be—

$$= 306{\cdot}366 + 85{\cdot}95 = 392{\cdot}316$$

or—

$$\left[\frac{165 \times 32 \times 36}{1 \times 36 \times 36}+\left(\frac{165 \times 46 \times 7\frac{1}{8} \times 26 \times 80}{1 \times 24 \times 3\frac{3}{8} \times 75 \times 50}\right)\left(\frac{36-32}{36} \times \frac{36}{36}+\frac{36-36}{36}\right)\right]$$

$$\times \frac{63 \times 50}{58 \times 25} = 392 \cdot 316$$

The revolutions of the spindle per minute are—

$$\frac{165 \times 56 \times 50}{1 \times 58 \times 25} = 306 \cdot 366$$

The number of coils of rove wound upon the bobbin per minute are therefore—

$$= 392 \cdot 316 - 306 \cdot 366 = 85 \cdot 95$$

The following will therefore represent the length of rove wound :—

$$85 \cdot 95 \times \frac{1\frac{1}{2} \times 22}{7} = 405 \cdot 193 \text{ inches per minute}$$

The front roller, in that time, makes—

$$\frac{165 \times 46 \times 40}{24 \times 115} \text{ revolutions}$$

or delivers—

$$\frac{165 \times 46 \times 40 \times 1\frac{1}{8} \times 22}{24 \times 115 \times 7} = 388 \cdot 928 \text{ inches of rove}$$

Therefore that length is stretched, if the rove is assumed to have no thickness, to 405·193 inches, or to the extent of 13·265 inches more than the rollers deliver; this is equal to nearly $4\frac{1}{4}$ per cent.

The particulars contained in Fig. 27 are those of a slubber frame, the differential being that known as Brooks and Shaw's. The action of this differential is readily understood. Applying the formula as in the previous examples—

$$n = m \pm a$$

for all conditions of working, the revolutions which the bobbin would make per minute, if the bottom cone was stopped, or if the twist wheel was 0, are—

$$= (m \pm a) \times \frac{74 \times 50}{52 \times 24}$$

Here—

$$m = \mathrm{M}t$$

$$a = \mathrm{A} - \mathrm{A}t$$

$$t = \frac{30 \times 18}{18 \times 37}$$

$$\mathrm{M} = 200, \text{ and}$$

$$\mathrm{A} = 0$$

$$\left[0 \pm \left(\frac{200 \times 46 \times 6\tfrac{13}{16} \times 30 \times 20 \times 56}{\times 32 \times 3\tfrac{1}{2} \times 41 \times 40 \times 64}\right) - \left(\frac{200 \times 46 \times 6\tfrac{13}{16} \times 30 \times 20 \times 56 \times 30 \times 18}{32 \times 3\tfrac{1}{2} \times 41 \times 40 \times 64 \times 18 \times 37}\right)\right] \times \frac{74 \times 50}{52 \times 24} = 100{\cdot}5$$

The sign $\pm$ in the last instance is determined by the directions of M and A; when they move in the same direction it is $+$, and when opposite it is $-$.

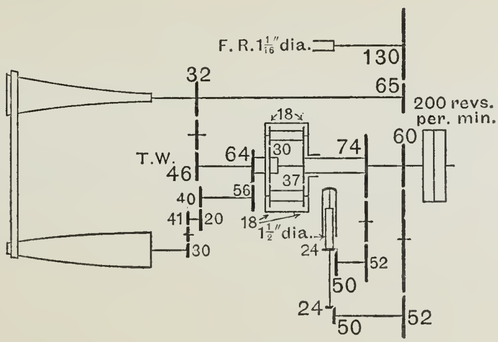


Fig. 27.

The revolutions of the bobbin per minute, when the cone strap is in the initial position and M and A are in motion, as per conditions in the figure, may be ascertained by adding the speed under the two sets of conditions together, *i.e.*—

$$480{\cdot}77 + 100{\cdot}5 = 581{\cdot}27$$

obtained as follows :—

$$\left[\frac{200 \times 30 \times 18}{18 \times 37} + \left(\frac{200 \times 46 \times 6\tfrac{13}{16} \times 30 \times 20 \times 56}{32 \times 3\tfrac{1}{2} \times 41 \times 40 \times 64}\right) - \left(\frac{200 \times 46 \times 6\tfrac{13}{16} \times 30 \times 20 \times 56 \times 30 \times 18}{32 \times 3\tfrac{1}{2} \times 41 \times 40 \times 64 \times 18 \times 37}\right)\right] \times \frac{74 \times 50}{52 \times 24}$$

therefore, of these the bobbin would make—

$$\left(\frac{200 \times 30 \times 18}{1 \quad \times 18 \times 37} \pm 0\right) \times \frac{74 \times 50}{52 \times 24} = 480\tfrac{10}{13} \text{ revolutions per minute}$$

Calculating directly from the spindle to the bobbin, the revolutions of the latter per one of the former would be—

$$\left(\frac{24 \times 52 \times 30 \times 18}{50 \times 60 \times 18 \times 37} \pm 0\right) \times \frac{74 \times 50}{52 \times 24} = 1$$

The revolutions of the bobbin, assuming the bottom cone to rotate whilst M is at rest and the diameters of the top and bottom cones, at points opposite the centre of the cone strap whilst in the initial position, being $6\frac{13}{16}$ inches and $3\frac{1}{2}$ inches respectively, would be—

$$= [162{\cdot}162 + (179{\cdot}177 - 145{\cdot}278)] \times \frac{74 \times 50}{52 \times 24}$$

$$= (162{\cdot}162 + 33{\cdot}899) \times \frac{74 \times 50}{52 \times 24} = 581{\cdot}27$$

The rate at which the coils are wound during the first layer laid upon the bobbin is therefore—

$$581{\cdot}27 - 480{\cdot}77 = 100{\cdot}5 \text{ per minute}$$

The rate at which the rove is wound—

$$100{\cdot}5 \times 1\tfrac{1}{2} \times \tfrac{22}{7} = 473{\cdot}78 \text{ inches per minute}$$

The rate at which the front roller revolves—

$$200 \times \frac{46 \times 65}{32 \times 130} \text{ revolutions per minute} = 143\tfrac{3}{4}$$

The length delivered per minute by the front roller is—

$$200 \times \frac{46 \times 65}{32 \times 130} \times \frac{1\frac{1}{16}'' \times 22}{7} = 480{\cdot}0 \text{ inches}$$

The amount of rove which the bobbin winds in excess of that delivered by the front roller, assuming the radius of the winding circle of the rove $\frac{3}{4}$ inch—

$$= 480 - 473{\cdot}78 = 6{\cdot}22 \text{ inches}$$

or 1·3 per cent. less than that delivered.

The Speed in Fly Frames.—The speed at which the most satisfactory results are obtained vary with the working

conditions: the kind of work, the efficiency of the machines, skill and organization of the operatives.

Data on this subject should not be regarded as inflexible, but should be subjected to modification such as experience and developments, in the application, suggest.

The rates of spindle speeds attainable in modern makes of these frames, fitted with long collars, are—

Kind of cotton.	Slubber.	Intermediate.	Rover.	Jack.
Egyptian	450–500	650–800	950–1050	1000–1150
American	550–700	700–850	1050–1200	
Indian	600–700	750–850	1050–1200	

Adopt the highest beneficial speed and fix other conditions so that the whole of the machinery is continuously occupied in producing the required amount.

Proportions of Machinery in the Carding Department.—The fly-frame processes usually consist of three stages, but sometimes two and four are adopted. They are named respectively: slubber, intermediate, rover; slubber, rover; slubber, intermediate, rover, jack.

The number of these processes expedient depends upon the extent of the attenuation desired prior to spinning, and also, to some extent, upon the character of the cotton. Uniform stapled cottons are influenced less detrimentally by high drafts. Beyond a certain count the roving can be more economically prepared by an additional process. That limit cannot be fixed. It ranges upwards from between 15 and 20. The draft necessary to attenuate the drawing sliver to the desired extent for spinning is distributed amongst these two, three, or four processes in certain proportion (see p. 142).

In the machinery from the card onward to spinning it is customary to arrange the machinery in what are termed "preparations." A "preparation" consists of one slubber and all the other machinery necessary to prepare as well as to deal with its product. Such may be literally expressed as a slubber

and its complement. The following are the proportions of the machinery forming one preparation in—

	Cards.	Combers.	Draw frames.	Slubbers.	Intermediates.	Rovers.
Mule spinning	9 to 15	6 to 10	One frame of 18 to 24 dels. divided into three heads	One frame of 80 to 100 spindles	Two frames of 120 to 140 spdles. each	Four frames of 168 to 200 spindles, each.
Ring frames	Ditto	Ditto	Ditto	Ditto	Ditto	Five frames of 168 to 200 spindles.

The following are therefore the proportions of the above-named machines per slubbing spindle, respectively:—

		(deliveries)	(spindle)	(spindles)	(spindles)
0·1125–0·15	0·075–0·1	0·075-0·01	1·0	2·72–3·0	8·0–10·0

These proportions are those ruling in the bulk of spinning mills, and it is therefore reasonable to assume that they represent what is found most useful.

Drafts in Fly Frames.—The following are the factors controlling the division of the combined attenuation required in the respective fly frame processes:—

(1) Number of spindles of each type available;
(2) Speeds practicable;
(3) Extent of the combined attenuation required;
(4) Efficacious twist constant at each stage;
(5) Time lost at each stage.

These decided, for example, as given below, the respective drafts are arrived at as follows:—

Speed of spindles (per minute).	Slubber, 550.	Intermediate, 800.	Rover, 1200.
Per cent. time lost (approx.)	15	10	7
Twist constant	1	1	1
Proportions of spindles .	1	3	8
Count at each stage . .	C_1	C_2	C_3
Draft at each stage . . .	x_1	x_2	x_3
Total draft in these fly frames	This is always fixed by the count of roving decided upon for spinning and by the weight of sliver, most suitable, at the drawing frame.		

With fixed quantities of fly frames and spinning machinery available, *the adoption of the most* suitable *spindle speeds decide the drafts* by fixing their capacity in respect of their twisting rates. The demands of the spinning machines having been ascertained, the highest rate at which the roving spindles can be satisfactorily run will decide the most suitable count of roving to prepare and also the draft in the spinning machine. Let the count of roving be denoted as x lbs. per spindle, and C_3, C_2, C_1, the counts of the roving, intermediate, and slubbing, respectively; then the amounts required from the intermediates and slubber will be—

Intermediate, 3 per 8 roving, spindles, $\frac{8x}{3}$

Slubber, 1 per 8 roving, spindles, $\frac{8x}{1}$

Hence the following equations:—

Roving—

$$\frac{1200 \times \frac{93}{100}}{\sqrt{C_3} \times C_3 \times 36 \times 840} = x \text{ lbs. per minute per spindle}$$

Intermediate—

$$\frac{800 \times \frac{90}{100}}{\sqrt{C_2} \times C_3 \times 36 \times 840} = \frac{8x}{3} \text{ lbs. per minute per spindle}$$

Slubber—

$$\frac{550 \times \frac{85}{100}}{\sqrt{C_1} \times C_1 \times 36 \times 840} = 8x \text{ lbs. per minute per spindle}$$

From the above equations the separate values of C_1, C_2, and C_3 may be found, when the sum of the draft involved in this production is known. The sum of the drafts in the rover, intermediate, and slubbing frames is found by ascertaining the weight per yard, or count, of the sliver at the finishing head of the draw frame that will produce the required weight when running at the most desirable speed, and comparing this with the count of roving required.

An example is provided by assuming the conditions, in respect of the counts, delivered, at the drawing and roving

frames: 0·2 and 6·0 respectively. Under these conditions the total draft or the attenuation in the slubber, intermediate, and roving frames would be $= \frac{6}{0 \cdot 2} \times (2 \times 2)$, the latter allow for the two doublings in each of the latter stages; = 120.

Therefore the weight produced per roving spindle per 55 hours

$$= \frac{55}{36 \text{ ins.} \times 840 \text{ yds.}} \times \frac{60}{\underset{(C_3)}{\sqrt{6}}} \times \frac{1200}{\underset{(C_3)}{6}} \times \frac{93}{100} = 8 \cdot 3 \text{ lbs.}$$

$$\left.\begin{array}{l}\text{The weight produced per intermediate} \\ \quad \text{spindle per 55 hours}\end{array}\right\} = \frac{8}{3} \times 8 \cdot 3 \text{ lbs.}$$

$$\therefore \quad \frac{55 \times 60 \times 800 \times 90}{36 \times 840 \times \sqrt{C_2} \times C_2 \times 100} = \frac{8}{3} \times 8 \cdot 3 \text{ lbs.}$$

$$\therefore \quad C_2\sqrt{C_2} = \frac{55 \times 60 \times 800 \times 90 \times 3}{36 \times 840 \times 100 \times 8 \times 8 \cdot 3} = 3 \cdot 55$$

$$\therefore \quad C_2 = 2 \cdot 33, \text{ the count of the intermediate rove}$$

$$\left.\begin{array}{l}\text{The weight produced per slubbing} \\ \quad \text{spindle per 55 hours}\end{array}\right\} = 8 \cdot 3 \times \frac{8}{1}$$

$$\therefore \quad \frac{55 \times 60 \times 550 \times 85}{36 \times 840 \times \sqrt{C_1} \times C_1 \times 100} = 8 \cdot 3 \times 8 \text{ lbs.}$$

$$\therefore \quad \sqrt{C_1} \times C_1 = \frac{55 \times 60 \times 550 \times 85}{36 \times 840 \times 8 \cdot 3 \times 8 \times 100} = 0 \cdot 615$$

$$\therefore \quad C_1 = 0 \cdot 725, \text{ count of the slubbing sliver}$$

The drafts in the respective fly frames may be now ascertained from the above counts, and they are as follows:—

Draft in the rover—

$$\frac{\text{count of roving} \times 2}{\text{count of intermediate}} = \frac{6 \times 2}{2 \cdot 33} = 5 \cdot 15$$

Draft in the intermediate—

$$\frac{\text{count of inter. rove} \times 2}{\text{count of slubbing}} = \frac{2 \cdot 33 \times 2}{0 \cdot 725} = 6 \cdot 43$$

Draft in the slubber—

$$\frac{\text{count of slubbing}}{\text{count of sliver}} = \frac{0{\cdot}725}{0{\cdot}2} = 3{\cdot}625$$

It is seen, from this procedure, that the drafts in these machines depend not only upon the proportions of spindles, but also on the other productive factors mentioned on p. 142, and numbered 2, 3, 4, 5.

PARTICULARS OF FLY FRAMES.

Machine.	Loss of time due to oiling, cleaning, and incidental stoppages apart from doffing.	Usual sizes of full bobbins.	Usual gauges.	Usual lifts.	Contents in ounces per bobbin.	Time lost per doff.
Rover . . .	$5\frac{1}{2}$ %	$3\frac{1}{2}''$ to $3\frac{3}{4}''$	$5''$ to $5\frac{1}{4}''$	$7''$ and $8''$	8 to 11 ozs.	12 mins.
Intermediate	„	$4\frac{1}{4}''$ to $4\frac{1}{2}''$	$6''$ to $6\frac{1}{2}''$	$9''$ and $10''$	18 to 24 ozs.	„
Slubber . .	„	$5\frac{3}{4}''$	$9''$	$10''$ to $12''$	24 to 30 ozs.	„

The Production in Fly Frames.—To estimate the production of the above-named machines. Rover, spindles making 1150 revolutions per minute; hours worked, 55. Allow $5\frac{1}{2}$ per cent. for loss occasioned through breakages, and proceed as follows:—

$$\left\{\begin{array}{l}\text{Weight of contents}\\ \text{of full bobbin in}\\ \text{ounces}\end{array}\right\} \times \frac{100}{94{\cdot}5} = \left\{\begin{array}{l}\text{the weight that would be delivered}\\ \text{in the period required to make a}\\ \text{doff, if no stoppages} = (x)\end{array}\right.$$

$$\frac{1150 \times 16}{\text{twist per inch} \times 36 \times 840 \times \text{count}} = \left\{\begin{array}{l}\text{the weight in ounces}\\ \text{delivered by the roller}\\ \text{in one minute, uninter-}\\ \text{rupted working} = (y)\end{array}\right.$$

$$\frac{x}{y} = \text{minutes required to fill a set of bobbins}$$

$$\frac{x}{y} + \text{time lost in doffing} = \left\{\begin{array}{l}\text{minutes taken to fill and}\\ \text{doff a set of bobbins} = (z)\end{array}\right.$$

$$\frac{55 \times 60}{z} \times \left\{\begin{array}{l}\text{weight of contents of}\\ \text{a bobbin in ounces}\end{array}\right\} = \left\{\begin{array}{l}\text{production per spindle in}\\ \text{ounces per week}\end{array}\right.$$

Therefore, with the count produced by the roving 6, the twist constant 1·2, and the contents of a full bobbin 10 ozs., the production per spindle in ounces and hanks per 55 hours, respectively, would be—

$$\left.\frac{55 \times 60}{\dfrac{10 \times \dfrac{100}{94\cdot5}}{\dfrac{1150 \times 16}{\sqrt{6} \times 1\cdot2 \times 36 \times 840 \times 6}} + 12}\right\} \times 10 = 103\cdot52 \text{ ozs.}$$

$$\text{Hanks} = \frac{103\cdot52 \times 6}{16} = 38\cdot8125$$

With the count produced by the intermediate 2·33, the twist constant 1·2, and the contents of a full bobbin 22 ozs., the production per spindle in ounces and hanks per 55 hours respectively, would be—

$$\left.\frac{55 \times 60}{\dfrac{22 \times \dfrac{100}{94\cdot5}}{\dfrac{800 \times 16}{\sqrt{2\cdot33} \times 1\cdot2 \times 36 \times 840 \times 2\cdot33}} + 12}\right\} \times 22 = \frac{3300}{235 + 12} 22 = 294 \text{ ozs.}$$

$$\text{Hanks} = \frac{294 \times 2\cdot33}{16} = 42\cdot8$$

With the count produced by the slubber 0·715, the twist constant 1·2, and the contents of a full bobbin 28 ozs., the production per week in ounces and hanks per 55 hours respectively, would be—

$$\left.\frac{55 \times 60}{\dfrac{28 \times \dfrac{100}{94\cdot5}}{\dfrac{550 \times 16}{\sqrt{0\cdot725} \times 1\cdot2 \times 36 \times 840 \times 0\cdot725}} + 12}\right\} \times 28 = 1055 \text{ ozs.}$$

$$\text{Hanks} = \frac{1055 \times 0\cdot725}{16} = 47\cdot8$$

Examples of arranging the speeds, drafts, and counts to suit the mill specification. The following being the quantities of each kind of machinery, ascertain the suitable speeds, drafts, and counts.

Spinning spindles, mule—

	Spindles.
32 pairs weft $1\frac{1}{8}''$ gauge, $64'' + 4''$ draw . .	83,688
16 ,, twist $1\frac{3}{8}''$,, ...	34,488
Total spindles	118,176

The weft are engaged upon, average counts, 46^s
,, twist ,, ,, ,, 36^s

The production of these per $55\frac{1}{2}$ hours would be about $27\frac{1}{2}$ hanks of 46^s W.; $29\frac{1}{4}$ hanks of 36^s T.

The other machines—

	Roving.	Intermediate.	Slubber.	Dr. F.R.	Cards.	Scutchers.
Number of frames	60	24	12	12	120	8
Spindles or heads	176	140	96	{3 heads 2×4 of 8 dels. each}		4 laps up
Gauge	8 in $20\frac{1}{2}''$	8 in $26''$	4 in $19''$	18	$45''$	$45''$
Lift	$7''$	$10''$	$10''$			

Reasonable allowances in such a mill—

	Doffing.	Cleaning.	Stoppages.	Other loss.	Weight on bobbin.
	mins.	hrs.	mins. per doff	per cent.	ozs.
Mule	8	$2\frac{1}{2}$	—	$2\frac{1}{2}$	—
Rovers	12	,,	12	,,	11
Intermediates .	,,	,,	,,	,,	22
Slubbers . . .	14	,,	14	,,	28

Suitable roving for the above counts of yarn: $5\frac{1}{2}$ for weft and $4\frac{1}{2}$ hank for the twist.

The relative productive rates in the roving frames—

$$\text{Count } 5\tfrac{1}{2} \times \sqrt{5\tfrac{1}{2}} = \text{time per lb. } 5\tfrac{1}{2}$$
$$\text{,, } 4\tfrac{1}{2} \times \sqrt{4\tfrac{1}{2}} = \text{ ,, } 4\tfrac{1}{2}$$

If all $5\frac{1}{2}$-hank rovings were produced, the total weight would be—

$$\frac{28160 \times \sqrt{4\frac{1}{2}} \times 4\frac{1}{2}}{\sqrt{5\frac{1}{2}} \times 5\frac{1}{2}} = 20{,}777 \text{ lbs.} + 50{,}280 \text{ lbs.} = 71{,}057 \text{ lbs.}$$

The amount of $4\frac{1}{2}$-hank roving required per week is 28,160 lbs.

The number of roving spindles required to prepare 50,280 lbs. of $5\frac{1}{2}$-hank must be—

$$10{,}560 \text{ total roving spindles} \times \frac{50280}{71057} = 7472, \text{ say } 42 \text{ frames}$$

Leaving 18 frames for the $4\frac{1}{2}$ hank.

Another way of arriving at the number of roving spindles to engage on each count is—

50,280 lbs. of $5\frac{1}{2}$ hank	=	276,540 hanks
28,160 lbs. of $4\frac{1}{2}$,,	=	126,720 ,,
		403,260 ,,

Therefore, if 60 frames of 176 spindles produce the above, and the respective productive ratios are—

For $4\frac{1}{2}^s$, $4\frac{1}{2} \times \sqrt{5\frac{1}{2}}$ in hanks or length
,, $5\frac{1}{2}^s$, $5\frac{1}{2} \times \sqrt{4\frac{1}{2}}$,, ,,

then the number of frames required for 126,720 hanks of $4\frac{1}{2}^s$—

$$= 60 \times \frac{126720}{403260} \times \frac{\sqrt{4\frac{1}{2}}}{\sqrt{5\frac{1}{2}}} = 18 \text{ frames}$$

and for 276,540 hanks of $5\frac{1}{2}^s$—

$$= 60 \times \frac{276540}{403260} \times \frac{\sqrt{5\frac{1}{2}}}{\sqrt{4\frac{1}{2}}} = 42 \text{ frames}$$

The production of the fly frames, drawing frames, and cards, in pounds, must be as follows, allowing $\frac{1}{2}$ per cent. for waste at each stage :—

$5\frac{1}{2}$ hank : Production, in pounds, per roving spindle—

$$\frac{50280 \times 100}{42 \times 176 \times 99\frac{1}{2}} = 6{\cdot}834$$

$4\frac{1}{2}$ hank : Production, in pounds, per roving spindle—

$$\frac{21860 \times 100}{18 \times 176 \times 99\frac{1}{2}} = 8 \cdot 9\dot{3}$$

Production, in pounds, per intermediate spindle. All these frames making the same count—

$$\frac{78440 \times 100}{3360 \times 99} = 23 \cdot 6$$

Production, in pounds, per slubbing spindle—

$$\frac{78440 \times 100}{1152 \times 98\frac{1}{2}} = 69 \cdot 12$$

Production, in pounds, per draw frame delivery—

$$\frac{78440 \times 100}{96 \times 98} = 834 \text{ lbs.}$$

Weight per card (see later).

The Speeds of the Spindles in the Roving Frames.—Taking the twist constants at 1·2 in each of the fly frames, and the stoppages and allowances as indicated, proceed to ascertain the rate of rotation of the spindles.

Roving, $5\frac{1}{2}$ hank : The doffs per week—

$$\frac{6 \cdot 834 \times 16}{11} = 9 \cdot 94$$

The time to complete a set of bobbins and doff—

$$= \frac{(55\frac{1}{2} - 2\frac{1}{2})\frac{97\frac{1}{2}}{100} - 119 \cdot 28 \text{ (mins. per doffing)}}{9 \cdot 94} = 5 \text{ hours}$$

Speed of spindles ; revolutions per minute—

$$\therefore \frac{11 \times 5\frac{1}{2} \times 840 \times 36 \times \sqrt{5\frac{1}{2}} \times 1 \cdot 2}{16 \qquad 5 \times 60} = 1073$$

Roving, $4\frac{1}{2}$ hank : The doffs per week—

$$\frac{8 \cdot 9\dot{3} \times 16}{11} = 12 \cdot 993$$

The time to complete a set of bobbins and doff—

$$= \frac{(55\frac{1}{2} - 2\frac{1}{2})\frac{97\frac{1}{2}}{100} - 12{\cdot}993 \times 12 \text{ mins.}}{12{\cdot}993} = \frac{49{\cdot}1}{12{\cdot}993} = 3{\cdot}78 \text{ hours}$$

The Count of the Intermediate Roving.—The weight on an intermediate bobbin = 22 ozs.

Revolutions of spindle per minute, 800; allowances: 12 minutes each doff, and $2\frac{1}{2}$ per cent. after $2\frac{1}{2}$ hours for cleaning.

$$\text{Time lost in doffing} = \frac{23{\cdot}6 \text{ lbs.} \times 16}{22} \times 12 = 206 \text{ mins.}$$

$$\text{Nett time working} = 53 \text{ hrs.} - 206 \text{ mins.} \times \frac{97\frac{1}{2}}{100} = 2887 \text{ mins.}$$

$$\therefore \text{ the count} = \frac{\frac{25}{3}}{\dfrac{24{\cdot}3 \times 7000}{\left\{\dfrac{2887 \times 800}{1{\cdot}2\sqrt{C} \times 36}\right\}}}$$

$$= \frac{25 \times 2887 \times 800}{3 \times 24{\cdot}3 \times 7000 \times \sqrt{C} \times 1{\cdot}2 \times 36}$$

$$\text{The count} = \frac{2{\cdot}63}{\sqrt{C}}$$

$$\therefore \text{ count} \times \sqrt{\text{count}} = 2{\cdot}63$$

$$\therefore \text{ count} = 1{\cdot}90$$

The Count of the Slubbing Rove.—The weight of the slubbing bobbin = 28 ozs.

Revolutions of spindles, 600; allowances: 14 minutes per doff, and $2\frac{1}{2}$ per cent. after $2\frac{1}{2}$ hours for cleaning.

The production required per spindle per week = 69·12 lbs.

$$\text{Time lost in doffing} = \frac{69{\cdot}12 \times 16}{28} \times 14 = 553 \text{ mins.}$$

$$\text{Nett time working} = 53 \text{ hrs.} - 553 \text{ mins.} \times \frac{97\frac{1}{2}}{100} = 2547 \text{ mins.}$$

$$\text{The count} = \frac{\frac{25}{3}}{\frac{69{\cdot}12 \times 7000}{\left\{\frac{2547 \times 600}{1{\cdot}2\sqrt{C} \times 36}\right\}}}$$

$$= \frac{25 \times 2547 \times 600}{3 \times 69{\cdot}12 \times 7000 \times 1{\cdot}2 \times \sqrt{C} \times 36}$$

$$\text{The count} = \frac{0{\cdot}663}{\sqrt{C}}$$

$$\text{Count} \times \sqrt{\text{count}} = 0{\cdot}737$$

The Count of the Sliver at the Drawing Frame.—Third head; weight per delivery, 834 lbs.; speed of F.R., 320; $1\frac{3}{8}$ inch diameter; allowances: $2\frac{1}{2}$ hours for cleaning and $2\frac{1}{2}$ hours for breakages.

Length delivery per week in yards

$$= 320 \times \frac{1\frac{3}{8}}{36} \times \frac{22}{7} \times 60 \times 53 \times \frac{97\frac{1}{2}}{100}$$

Weight of the sliver delivery in grains per yard

$$= \frac{834 \times 7000 \times 36 \times 7 \times 100}{320 \times 1\frac{3}{8} \times 22 \times 60 \times 53 \times 97\frac{1}{2}} = 49 \text{ grains}$$

Drafts.

The Drafts up to this stage.

$$\text{Slubber} = \frac{49}{\frac{1}{0{\cdot}737} \times \frac{25}{3}} = 4{\cdot}33$$

$$\text{Intermediate} = \frac{1{\cdot}90 \times 2}{0{\cdot}737} = 5{\cdot}16$$

$$\text{Rover for } 5\tfrac{1}{2} = \frac{5\frac{1}{2} \times 2}{1{\cdot}9} = 5{\cdot}8$$

$$\text{Rover for } 4\tfrac{1}{2} = \frac{4\frac{1}{2} \times 2}{1{\cdot}9} = 4{\cdot}73$$

Weight of Card the Sliver.—Number of cards, 120; allow 4 for grinding. Hours worked, actual, 55, less $2\frac{1}{2}$ per cent.—

$$\frac{78440}{116} \times \frac{100}{97} = 697 \text{ lbs., say } 700$$

Revolutions of doffer 15 per minute 26 inches diameter. Weight of sliver per yard—

$$\frac{7000 \times 700}{15 \times \frac{26}{36} \times \frac{22}{7} \times 55 \times \frac{97\frac{1}{2}}{100} \times 60} = 44{\cdot}7 \text{ grains}$$

Analysis of the Action of Drawing Rollers.

Provided it is reasonable to assume that top rollers move at the rate of the cotton with which they are in contact, then Figs. 28 and 29 are records of the action of the drawing rollers in the various frames, under ordinary working conditions.

Fig. 29 gives the particulars of the observed relative movement in slubber, intermediate, roving, and spinning machines.

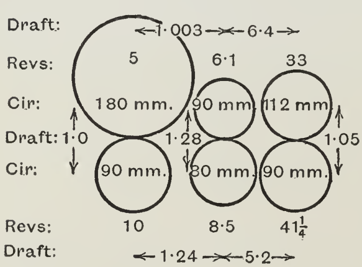


Fig. 28a.

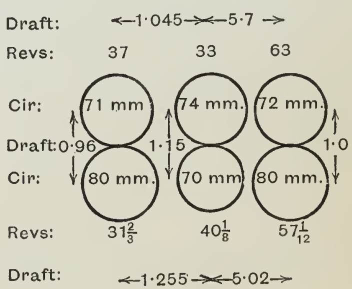


Fig. 28b.

Those, subsequently given, marked S.W. being of the self-weighted type, *i.e.* only the front top roller being weighted. The rest are of the ordinary weighted type.

Figs. 28a, 28b, show the manner of obtaining the data. The revolutions given are exclusively in respect of each pair of rollers (bottom and top). The relative rotation of the different lines are contained in the draft.

In these figures the rollers are arranged in the order of their

sequence, from left to right, back to front. Their circumference, revolutions, and draft are placed opposite the parts to which they refer.

The top line of numerals, in figs., are the observed ratio in the movement, or draft, in the top rollers, in each instance in terms of one of the precedent roller. Thus, 1·003 is that of the second in terms of 1 unit of movement of the first top roller.

The middle line of numerals relate to the difference in the movement of the top and the bottom rollers in terms of one of the latter.

The bottom line of numerals gives the ratio between the bottom

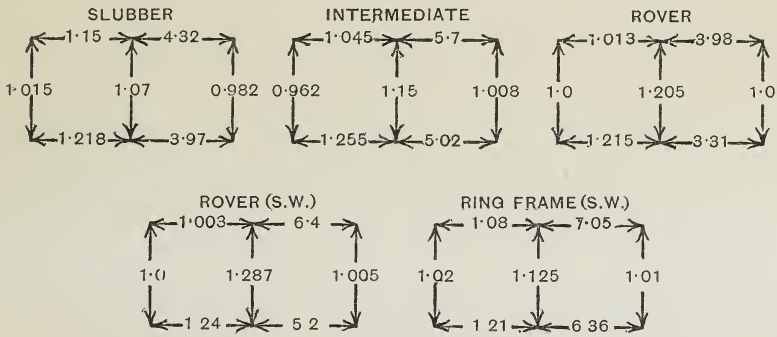


Fig. 29.

lines of rollers, in each instance, in terms of one of the precedent roller.

The features most noticeable, fig. 29, are the variations in the slip of the cotton, indicated by the movement of the respective top rollers. Except in the slubbing frame, this slip is considerable. With that exception the effect of the action of the first and second pairs of rollers appears to be only that attributable to the elasticity of the rove, being: 4·5 per cent. in the intermediate, 1·3 per cent. in one rover and 0·3 per cent. in the other rover, whilst it is almost 8 per cent. in the ring frame.

The Functions of the Respective Lines of Draw Rollers.—There are no reasons for suspecting that the ratios given in the last paragraph differ from those generally obtaining. Those results imply that the functions of the middle and back top rollers are, first, that of obtaining a uniform tension in that portion

of the rove between them; second, that of controlling the body of fibres not within the nip of the front pair of rollers. If these inferences are true, it cannot be an advantage to place the middle and back rollers widely apart, also in having a draft greater than that which covers the possible variations in tension and natural elasticity of the rove. For these reasons the draft between the first and second lines of rollers should always be low and in accordance with the last-named conditions. The difference in the condition in which the cotton is presented in the slubber, accounts for the almost complete realization of the draft between the first and second lines of rollers in that machine.

Hank Indicators.

Figs. 30 and 31 contain the gear common in the old and new types of hank indicators used in drawing, fly, and ring frames.

In Fig. 30 the dial is numbered from 0 to 100, and this part is connected with the front roller by the following train of wheels: A single worm on the front roller drives a worm wheel of 51 teeth, the subsequent gear being $\frac{6}{60}$, $\frac{5}{60}$, $\frac{5}{60}$, $\frac{5}{60}$, $\frac{\text{drivers}}{\text{driven}}$, the latter denominator being the dial wheel.

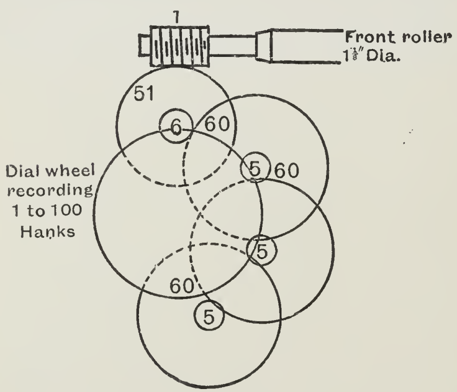


Fig. 30.

This form of indicator does not admit of reliable fractional readings, and for this reason is being discarded.

The above gear is only applicable to frames containing a front roller $1\frac{1}{8}$ inch in diameter.

An allowance of $2\frac{1}{2}$ per cent. is always made for breakages, so that the indicator registers $2\frac{1}{2}$ per cent. less than the actual length delivered.

In the present instance the actual length delivered per 100 hanks registered would be—

$$\frac{60 \times 60 \times 60 \times 60 \times 51 \times 1\frac{1}{8} \times 22 \times 1}{5 \times 5 \times 5 \times 6 \times 1 \times 36 \times 7 \times 840} = 103·04$$

This is equal to an allowance of 2·95 per cent.

The particulars of the size of roller and of the gear are now stamped upon each indicator.

Exercise 1.—Assuming the other gear as above, what size of worm wheel would be suitable for $1\frac{1}{4}$, $1\frac{3}{8}$, and $1\frac{1}{2}$ inch in diameters of rollers? *Ans.* 46, 41, 38.

Exercise 2.—What lengths, in hanks, would be delivered per 100 indicated, if the indicators used in frames, containing front rollers $\frac{7}{8}$, 1, $1\frac{1}{4}$, $1\frac{3}{8}$, and $1\frac{1}{2}$ inch in diameter, were geared as in Fig. 30, with the exception of the worm wheels, these latter being 65, 57, 46, 41, 38, respectively?

Ans. 102, 102·5, 103, 100·9, 102·3.

Exercise 3.—What weight would be produced in 10 hours per frame of 186 spindles if 9·4 hanks are recorded and the count of the rove is 3·5? *Ans.* 500 lbs.

Exercise 4.—At what rate would it be necessary to run the spindles per minute, if the loss of time, including doffing, was 5 per cent., the twist per inch 2·2, and the count $3\frac{1}{2}$, in order to register on the indicator 9·4 hanks in 10 hours? *Ans.* 1125.

In Fig. 31 there are three index discs, that on the left hand recording tens, that in the centre the units, and that on the right hand the decimals, each disc being numbered from 1 to 10 and each free upon the central spindle. The driving from the front roller is by a worm driving the 36, and thence to the decimal dial wheel; the gear is $\frac{1}{24} \times \frac{1}{4} \times \frac{8}{20}$. The units dial is driven from the decimal dial by a train $\frac{1}{4} \times \frac{8}{20}$, and the tens dial is driven from the latter by $\frac{1}{4} \times \frac{8}{20}$.

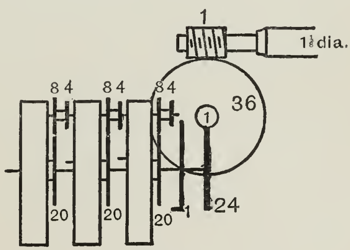


Fig. 31.

Thus the calculated length delivered per 100 recorded—

$$= \frac{20 \times 4 \times 20 \times 4 \times 20 \times 4 \times 24 \times 36 \times 9 \times 22 \times 1 \times 1}{8 \times 1 \times 8 \times 1 \times 8 \times 1 \times 1 \times 1 \times 8 \times 7 \times 36 \times 840}$$

= 101 hanks

EXERCISE 5.—What length in hanks would be delivered per 100 recorded if the 36 worm wheel is changed to 37? *Ans.* 103·8.

EXERCISE 6.—What length in hanks would be delivered per 100 recorded if the 36 and 34 worm wheels are changed to 35 and 25? *Ans.* 102·3.

EXERCISE 7.—What weight of 4^s roving will be produced in a frame containing 200 spindles per 52 hanks recorded by an indicator, as in Fig. 31, assuming the loss is actually $2\frac{1}{2}$ per cent.? *Ans.* 2560 lbs.

LENGTH OR FULL BOBBIN STOP MOTIONS.

Fig. 32 represents a length stop motion applicable in fine work when a number of sets of bobbins are required containing exactly the same length. This motion is very convenient in the preparation of special rove for spinning samples and small quantities, and when not more than the roving necessary to make the yarn is required.

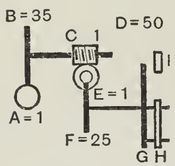


FIG. 32.

A is a worm on the front roller, B a worm wheel, C a worm on the latter, driving D, D is compounded with the worm E; E drives F, and this is attached to a peg disc G; a suspended catch H operates the strap control release bar I at each revolution of G.

B is the change wheel.

The length of roving delivered per action of this motion with the front roller $1\frac{1}{8}$ inch in diameter $= \frac{25}{1} \times \frac{50}{1} \times \frac{35}{1} \times \frac{1\frac{1}{8} \times \frac{22}{7}}{36}$ $= 4295$ yards.

EXERCISE 1.—What size of change wheel (35) would be required to make bobbins containing 21 leas, 73 yards? *Ans.* 27.

EXERCISE 2.—A roving frame containing 200 spindles is required to prepare 500 lbs. of 20^s roving for a mule using double roving and containing 1000 spindles. What change wheel will give the nearest approach to the necessary length on each bobbin? *Ans.* 34.

EXERCISE 3.—What lengths of roving will be delivered by the front roller per action of this part with change wheels ranging from 25 to 45 respectively?

MULE CALCULATIONS.

The Gearing in Mules.—The parts engaged during spinning receive their motion from the rim shaft.

Those parts that are engaged whilst spinning is in abeyance

receive their motion through the shaft designated the backing-off and taking-up motions shaft.

The rim and the backing-off and taking-up motions shaft receive their movement from the line shaft, usually through the medium of a counter shaft. This system of driving obtains better control than when driven direct from the line shaft.

The draft gear in these machines is identical with that in the fly, and ring frames. Reference to those will make clear all that can be said respecting drafts and changes in the counts in mules. Examples are given later in this section.

(*a*) The spindles are connected with the rim shaft by an indirect train, comprising two direct trains of pulleys and bands, the rope from the pulley on the rim shaft being guided to one on the tin roller shaft by suitable carriers. The last-named shaft is coupled to a series of long drums known as tin rollers, these drive bands conveying the motion to grooved pulleys or wharves on the spindles. The rim pulley is the usual change part in this train. In some makes slight changes are also arranged for, in the size of the tin roller pulley; it is then made in two detachable portions. When a change in the speed of the spindle is expedient, this change is used for altering the rate of rotation of the spindle and its relation with other parts.

(*b*) The connecting gear from the rim shaft to the front roller, in most makes of mules, consists of an indirect train of six wheels, arranged in three direct or simple trains. These are conveniently mounted to enable at least one driver and one driven wheel to be changed. A change in the value of this train is necessary when an alteration in the relation of the rollers with the rim shaft is required. Also, when a change in the speed of the spindle is desired, but without any alteration in the relation between this part and the rollers.

(*c*) The front roller is connected with the back roller by an indirect train of four wheels comprising two direct trains. These wheels are named the draft wheels and, respectively, the front roller, crown, pinion, and back roller wheels. The two latter are conveniently mounted for changing, being the medium of alterations in the draft.

The middle back rollers are connected by a direct train,

comprising three wheels, in the same manner as in fly frames.

(*d*) The carriage, of spindles, is drawn outward by two sets of ropes attached to drums secured upon the back shaft. The latter being connected with the front rollers by an indirect train of five wheels, these comprise two direct trains. Those wheels are conveniently arranged to enable a driven and a driver to be changed. They are known as the gain and gain boss wheels respectively, the last named driving the wheel on the back shaft. These wheels are the medium of alterations in the rate of movement of the carriage, relative to that of the front roller; and therefore they control the tension in the yarn during spinning. In spinning the poorer classes of yarn gain is often a minus quantity. The "jacking," "ratching," or stretching motion is the means by which yarns may be improved, during spinning, by the elimination of soft thick portions. The motion is not usually adopted for other than fine work, because it reduces the production considerably, thereby increasing the cost of spinning. It is the medium for actuating the backshaft train at $\frac{1}{4}$ to $\frac{1}{5}$ the normal rate, and during this action the rollers are either at rest or moving at an almost imperceptible rate. This action has the effect of moving the carriage at from $\frac{1}{4}$ to $\frac{1}{8}$ of the normal speed, and hence the yarn is stretched and made more uniform by the thicker portions being attenuated. In accomplishing this successfully it is necessary that the yarn should only receive a portion of its twist prior to this action. The exact amount cannot be stated, because it varies in extent, with the circumstances, from $\frac{3}{8}$ to $\frac{7}{8}$ of that required, being lowest in the best-prepared and long-stapled cottons. When the completed yarn contains above the standard twist, much twisting is necessary "at the head." This, if completed at the ordinary speed of the spindle, results in a considerable loss of time. The gearing, comprised in this motion, varies in the different makes. Three types are contained in Figs. 34, 36, 37, and 38.

(*e*) The slow roller turning, or "receding," motion, contained in Figs. 34 and 36, consists of a train of wheels in uninterrupted connection with the rim shaft. This prevents the front roller from being at rest whilst the rim shaft is rotating in the

"twisting" direction. This action eliminates the tendency of "twisting down" of the ends during jacking. It is constructed with an escapement allowing the front roller to be driven by the major movement active.

The twisting motion, shown in Figs. 34 and 36, controls the twist. It is only used in those mules wherein the twist cannot be, advantageously, completely inserted whilst the carriage is moving, necessitating the completion of twisting with the carriage at rest at the "head." This motion controls the rim shaft driving strap. The mechanism consists of a detent catch for holding the strap fork lever, this is released by a "tumbler" operated by a train of wheels that are in connection with the rim shaft. One or two of these wheels are mounted conveniently for changing. These change wheels are termed the twist wheels because they control the revolutions which the rim and the tin roller shaft and the spindles make per draw, and thus the twist inserted in the yarn.

The double speed motion, for rotating the spindles at two different rates, aims at the reduction of the time occupied in spinning, when "jacking" is in vogue, by actuating the spindles at the maximum rate throughout. Prior to jacking, the speed of the spindles must be in accordance with the resistance of the yarn. As the degree of twist increases and improves the strength of the yarn, the spindles are rotated at a higher speed, sometimes almost double the former rate. For this work two drums of different sizes may be employed, to drive the counter shaft alternately, as shown in Fig. 35.

Two different sizes of rims separately driven are also used for the same purpose.

The building motion consists of a mechanism for raising the range of movement of the directing faller wire so that the yarn is laid in layers, progressively ascending, upon the spindle. The rate of this movement determines the thickness of the body of yarn so formed, and therefore that of the cop. The parts actuating this movement are: a screw, which operates the withdrawal of the inclined plates supporting the copping rail, having a ratchet wheel secured to it—the latter being actuated, by the passage of a curved or inclined bracket secured to the

carriage front; an adjustable number of teeth per draw, through the medium of a pawl and pawl lever. The pawl lever, at each passage, is pushed prior to the termination of each outward movement of the carriage. The extent of this movement is adjusted by varying the inclination of the curved bracket, and also, by the use of screws of different pitch. Ratchet wheels are made a standard diameter by each maker, but with varying numbers of teeth. Whenever convenient the wheel is moved one tooth per draw only.

The Roller Delivery Motion, during Winding.—This motion usually consists of a direct train, composed of three wheels, for driving the front rollers during the inward run of the carriage. This is effected from the back shaft. The wheel on the latter, or that on the front roller, is furnished with an escapement that allows of the front roller being driven by the major movement active.

The winding motion is similar in construction in all the types of mules in general use. It consists of an actuating chain and chain barrel, with a direct train connection to a wheel on the tin roller shaft. This generally consists of two wheels, one of these communicating the movement to the shaft through an escapement that allows the tin roller to be always under the influence of the major movement. The rate at which the chain is unwound from the barrel controls the spindle. The rate of the unwinding of the chain is determined by the radius described by the other end of the chain. This is secured to a nut on a screw within the quadrant arm, the screw being actuated in one direction only, and this increases the radius described by the nut. This is the function of the automatic winder governing motion.

The backing-off and taking-in motion is shown in each of the Figs. 33 and 34. This is the same in all types of mules except that the value of the train and rate of movement are varied.

During recent years considerable improvement has been made in this motion. The change enables the tension, to which the yarn is subjected, to be adjusted in the most desirable degree. This is obtained by the introduction of parts which control the engagement of the backing-off friction, and allow this to be deferred until the momentum of the rim shaft is reduced to

the desired degree. The effects are that backing-off frictions may be run at slower rates and are more reliable. They can be adjusted more definitely to the requirements.

The Hastening Motion.—The usefulness of self-acting mules for the finest counts has been improved by the introduction of figure 35 type of this motion. Its aims are to secure the desired adjustment in the number and spacing of the coils wound upon the spindle at the termination of winding. Also, to relieve thereby the strain upon the yarn during the action of backing-off.

Twist.—The following are the common twist constants' standards in connection with the ordinary qualities of single yarns:—

Description of the cotton and yarn.	$\sqrt{\text{count}} \times$ constant $=$ twist per inch.
Egyptian weft	3·18
American „	3·25
Doubling „	3·49
American twist	3·75
Egyptian „	3·606
Ring „	4·0

The Conditions governing the Various Changes in the Wheel Train Values in Mules.—(1) The speed of the spindle should be the highest consistent with the quality of yarn required, and with due regard to the wear and tear of the machine. The rim pulley is the medium of alteration.

(2) The twist required in the yarn must conform with the standards given above. This controls the sizes of the rims, twist and speed wheels.

(3) The most beneficial rate at which the carriage may be moved outward often restricts the speed at which the spindles run, and determines the size of the speed wheel. Five draws in 60 seconds is considered the maximum rate at which the carriage may be worked.

(4) The count of the roving available and that of the yarn desired.

(5) The "gain" or "drag" must be governed by circumstances; generally it is beneficial in attenuating the thick soft and breaking the weak parts of the yarn. At the same time it

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eliminates snarls, and is usually applied to the greatest extent practicable. This governs the relation between the movement of the carriage and rollers.

(6) "Jacking" or "ratch" can only be adopted when time and other circumstances permit. Generally it is only adopted to a very limited extent in other sections than the production of fine yarns. It is essential in the production of yarns of a superior quality; sometimes it is applied to the extent of as much as $4\frac{1}{2}$ inches in a draw of 60 inches.

(7) The "shaper" wheel governs the thickness of the cop.

In changing, the following precautions should be noted:—
(1) Avoid changing the twist by means of either the speed wheel or rim pulley before ascertaining whether a change in the spindle or carriage speed will be most beneficial, and to what extent each of these may be altered to advantage.

(2) Before changing the twist wheel, consider whether the proposed alteration can be accomplished to greater advantage by means of the rim or speed wheel.

(3) Always notice and collect data of the difference between the calculated and actual results. These vary very considerably in the non-positive gear, and can only be satisfactorily determined in this way.

(4) Check the accuracy of the effects of the draft. This is readily done at the spindle point by taking a sufficient number of ends, of a standard length, to enable the counts to be ascertained.

(5) The differences in the rate of spindles vary very much, and in ascertaining the actual twist, several tests should be made.

Calculations and other Particulars of the Various Trains of Gearing.

Fig. 33 is a plan of the gearing as found in the Hetherington mule for coarse and medium counts. The particulars relating to the driving of the rim shaft in this figure are—

Line shaft, 235 revolutions per minute; diameter of drum, 32 inches.

Counter shaft: fast and loose pulleys, 16 inches; driving drum, 28 inches diameters.

Revolutions of the rim shaft per minute—

$$= \frac{235 \times 32 \times 28}{16 \times 14} = 940$$

(*a*) *Revolutions of the spindles per minute*, when the rim pulley is 12 inches and the tin roller pulley 12 inches—

$$= \frac{940 \times 12 \times 6}{12 \times \frac{3}{4}} = 7520$$

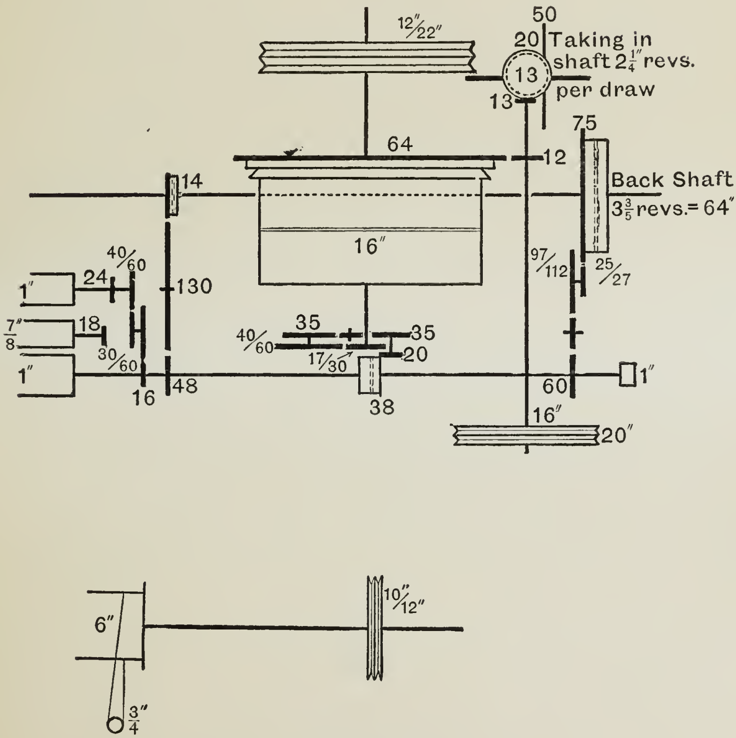

FIG. 33.

Therefore, the different speeds of the spindles obtainable by the range in the sizes of rims (12 to 22 inches) are =

Size of rim	12″	13″	14″	15″	16″	17″
Size of T.R.P.	12″					
Revs. of spindle per min.	7520	8150	8780	9420	10,050	10,680

Size of rim	18″	19″	20″	21″	22″
Size of T.R.P.	12″				
Revs. of spindle per min.	11,300	11,730	12,530	12,970	13,600

NOTE.—The actual will differ considerably from the calculated speed. The loss between the rim shaft and the spindle will be from 5 per cent. upwards, when the diameters of the surfaces in the train are measured in the customary way.

(*b*) The rate of rotation of the front roller relative to the spindles is varied in order to obtain the desired twist. The train connecting the front roller with the rim shaft is provided with suitable change gear for that purpose. The length delivered by the front roller during the outward run of the carriage, varies with the amount that the latter is desired to "gain." The movement by the carriage is from 68 inches to $58\frac{1}{2}$ inches, the former in mules for coarse, and the latter in those for fine, work. Assuming no "gain," the surface rates of the movement of the rollers and carriage correspond. Thus, with the front roller 1 inch in diameter and the draw 64 inches, the front roller makes—

$$\frac{64}{1'' \times \frac{22}{7}} = 20\tfrac{4}{11} \text{ revolutions per draw}$$

With the gearing from the rim shaft to the rollers arranged to give the quickest movement practicable within the range of change wheels stated: the largest driver and the smallest driven change wheels must be adopted; whilst in the train from the rim shaft to the spindles, the smallest drivers and the largest driven change wheels are necessary. Thus, neglecting the slippage arising in respect of the connection to the spindles, the revolutions of the spindle per $20\frac{4}{11}$ revolutions of the front roller would be—

$$20\tfrac{4}{11} \times \frac{38 \times 35 \times 40 \times 12 \times 6}{20 \times 35 \times 30 \times 12 \times \frac{3}{4}} = 412{\cdot}5$$

This represents the least twist per draw under the conditions named.

The twist per inch of yarn is therefore $\frac{412{\cdot}5}{64} = 6{\cdot}44$.

Thus, driver wheels and driven pulleys in this connection

reduce the twist inversely to changes in their size, whilst driven wheels and driver pulleys have the inverse effect. Therefore, the revolutions of the spindles per draw and the twist inserted per inch of yarn spun, with other change wheels than those given in the previous calculations, are as follows:—

(b_1)	Size of wheel on the rim shaft .	30	29	28	27	26	25	24
	Revs. of spindle per draw . .	412	426	441	457	475	494	515
	Twist per inch	6·44	6·66	6·88	7·14	7·43	7·82	8·05
	Size of wheel on the rim shaft .	23	22	21	20	19	18	17
	Revs. of spindle per draw . .	537	562	588	618	650	687	728
	Twist per inch	8·4	8·78	9·2	9·66	10·15	10·7	11·37

The revolutions of the spindles per draw possible with the range in speed-wheels (40–60), as specified, and the rest of the speed gear, excepting that a wheel of 17 teeth replaces the 30 on the rim shaft, as given in the previous calculation, are as follows:—The train from the rollers to the rim shaft when $\frac{38 \times 35 \times 40}{20 \times 35 \times 17}$ obtains 728 revolutions of the spindle per draw of $20\frac{4}{11}$ revolutions of the front roller. The 40 in this train is the speed wheel and therefore increasing the size of this will cause a reduced rate of movement, by the rollers and carriage, inversely to the change in these wheels, and hence proportionately more twist in the following amounts:—

(b_2)	Size of speed wheel . .	40	41	42	43 ...	50 ...	55 ...	60
	Revs. of spindle per draw	728	746	764	782 ...	910 ...	1002 ...	1092
	Twist per inch	11·37	11·6	11·9	12·2 ...	14·2 ...	15·6 ...	17

Further increases in the twist may be obtained by increasing the value of this train. This may be accomplished by reducing the number of the teeth contained in the wheel on the same axis as the speed wheel (35), and also the bevel wheel (20), driving that on the front roller shaft. The latter is named the front roller clutch bevel. By replacing these with 27 and 17 respectively, the range of twist obtainable when a 60-speed wheel is also employed, becomes—

$$20\tfrac{4}{11} \times \frac{38 \times 35 \times 60 \times 12 \times 6}{17 \times 27 \times 17 \times 12 \times \frac{3}{4}} = \begin{cases} \text{1670 revolutions of twist per} \\ \quad \text{draw} \end{cases}$$

Thus: when the speed wheel is altered to 40 the twist per draw becomes—

$$20\tfrac{4}{11} \times \frac{38 \times 35 \times 40 \times 12 \times 6}{17 \times 27 \times 17 \times 12 \times \frac{3}{4}} = 1112$$

Hence, the revolutions of the spindles per draw and the twist per inch obtainable by using the various sizes of speed wheels comprised in the range will be—

(b_3) Size of speed wheel	40	45	50	55	60
Revs. of spindle per draw	1112	1250	1390	1530	1670
Twist per inch	17·3	19·5	21·6	23·8	26·1

Assuming that, after the above-stated changes, the range in the sizes of the speed change wheels exhausted, further alteration in the twist would only be practicable by changes in the train of rope and band driving gear, from the rim shaft to the spindles. Such would, at the same time, alter the speed of the spindles as per paragraph (*a*). The changes in twist obtainable with the range in sizes of rim pulleys available, as specified, are—

Size of rim in inches		12	13	14	15	16
Twist per inch with the appended speed wheels	40 =	17·3	18·7	20·2	21·6	23·0
	60 =	26·1	28·3	30·5	32·6	34·8
Size of rim in inches		17	18	19	20	
Twist per inch with the appended speed wheels	40 =	24·5	25·9	27·4	28·8	
	60 =	37·0	39·2	41·4	43·5	

Basis 64 inches = draw.

It is customary, also, to make the tin roller pulley in halves in order to admit of its being changed: the range is from 10 inches to 12 inches. In the present instance the latter is in use. Altering this would affect the twist and at the same time the speed of the spindles in the inverse proportion.

(*c*) "**Gain**" **Changes.**—The back shaft, in pulling out the carriage, is assumed to make a fixed movement. This is not exactly the case, because this movement must be subject to variations arising through differences in the tension of the ropes and matters influencing the resistance to the movement of the carriage. For the purpose of calculation it is convenient to

make the assumption named. In the present instance, the movement of the back shaft is taken at $3\frac{3}{5}$ revolutions per draw, so that with the smallest gain boss (25–27) and gain wheels (97–112), and with the rest of the connecting gear from the front roller to the back shaft as specified, the length delivered by the front roller during this movement would be—

$$3\tfrac{3}{5} \times \frac{75 \times 97}{25 \times 60} = \left\{ \begin{array}{l} 17{\cdot}46 \text{ revolutions of the} \\ \text{front roller per draw} \end{array} \right.$$

and therefore $17{\cdot}46 \times 1 \times \frac{22}{7} = 54{\cdot}87$ inches delivered

With the following "gain" change wheels, the length delivered by the front roller and the "gain" would be :—

Gain wheel	97	98	99	100	101	102
Gain boss wheel	25	25	25	25	25	25
Inches delivered by rollers per draw	54·87	55·5	56·0	56·6	57·2	57·7
Gain in inches	9·13	8·5	8·0	7·4	6·8	6·3

Gain wheel	103	104	105	106	107	108	109
Gain boss wheel	25	25	25	25	25	25	25
Inches delivered by rollers per draw	58·3	58·8	59·4	60·0	60·6	61·1	61·7
Gain in inches	5·7	5·2	4·6	4·0	3·4	2·9	2·3

Gain wheel	110	111	112	112	111	110
Gain boss wheel	25	25	25	26	26	26
Inches delivered by rollers per draw	62·3	62·8	63·4	60·9	60·3	59·8
Gain in inches	1·7	1·2	0·6	3·1	3·7	4·2

Gain wheel	109	. . .	112	111	110	109	. . .
Gain boss wheel	26	. . .	27	27	27	27	. . .
Inches delivered by rollers per draw	59·3	. . .	58·7	58·2	57·7	57·1	. . .
Gain in inches	4·7	. . .	5·3	5·8	6·3	6·9	. . .

The changes in the length delivered by the front roller per draw during the outward run of the carriage, is directly proportionate to the changes in the size of gain, and inversely in respect of the gain boss, wheels.

Yarns highly twisted and of poor quality do not admit of the carriage gaining on the rollers. In such, the rollers more frequently deliver at a rate in excess of that moved by the carriage. This is sometimes as much as 10 per cent. In the production of the best qualities of yarn, when fully twisted as the carriage moves out, only a slight "gain" is practicable. "Gain" is

most applicable with low spindle speeds and when the yarns are not fully twisted during the movement of the carriage.

Changes in the Builder Wheel.—The approximate size of suitable builder wheel, may be ascertained as follows, when the size of cop required is known :—

$$\frac{b}{dc} = \text{suitable builder wheel}$$

b = the length in inches of the yarn contained in the cop.

d = the length wound in inches per draw.

c = the revolutions of the copping screw necessary in completing the cop.

b, is ascertained from the weight of the cop in grains, divided by the weight of one hank in grains, and multiplied by the inches per hank. Thus—

$$\frac{\text{nett weight of cop in grains}}{\dfrac{7000}{\text{count}}} \times 840 \times 36 = b$$

c, is ascertained by marking upon the spindle the length which the cop measures, from the cop bottom to the bottom of the chase; and then proceeding to turn the copping screw sufficient to pass the winding faller wire through the movement marked on the spindle, opposite. This must be done whilst the carriage is at rest, with the trail lever bowl on the ridge of the copping rail, and the revolutions of the screw counted.

Ascertaining the Suitable Builder Wheel in changing Counts.—Changing the counts affect the weight of the cops in the inverse proportions, and, assuming the tension of the yarn during winding proportional to the area of the yarn, the diameter of the cop would be affected in the inverse proportion to the $\sqrt{\text{counts}}$. Thus, the mode of calculating this wheel, in order to obtain a cop of constant size, should be as follows :—

$$\frac{\text{Present wheel} \times \sqrt{\text{required count}}}{\sqrt{\text{present count}}} = \text{required wheel}$$

NOTE.—A difference in the size of the cop must always result when the yarn is wound at other tension than inversely proportional to the difference in the area

of the yarn. Also, when the change alters the quality of the yarn in any way, the difficulty of adjusting the tension in the correct order is such that the above rule cannot be relied upon. The following rule will be found more reliable, but must not be regarded as accurate in all cases :—

$$\text{Required wheel} = \frac{\text{present wheel}\sqrt{\text{required count}}}{2\sqrt{\text{present count}}} + \frac{\text{present wheel} \times \text{required count}}{2 \times \text{present count}}$$

Ascertaining the suitable builder wheel in changing the size of the cops only—

$$\frac{\text{Present wheel (diameter of required cop)}^2}{\text{(diameter of present cop)}^2}$$

The following are exercises in calculating the alterations necessary to adapt the gearing in Fig. 33 for the work given. They are given in tabulated form because it is more convenient Allow 10 per cent. for slippage in the driving of the spindles from the rim shaft, and use the customary twist constants where the twist is not given.

Explanation of the tabulated exercises.—Those columns numbered 1 to 16 are separate exercises. The data required is signified by (?). Base the calculations for the builder wheel on that given in Exercise 1. The items referred to in each column are contained opposite in the first two columns on the left hand.

Exercise number	Minimum and maximum sizes.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Count and description of the yarn and cotton used: T=twist, W=weft		8^s T U.S.A.	10 T U.S.A.	14 W U.S.A.	16 T U.S.A.	20 W U.S.A.	24 T U.S.A.	28 W U.S.A.	32 T U.S.A.	36 T U.S.A.	42 W U.S.A.	50 T U.S.A.	60 W U.S.A.	80 T Egy.	72 W Egy.	84 W Egy.	100 W Egy.
Count of the rove and whether single or double in the creel. s=single, d=double		1½ s	2 s	2¼ s	2½ s	2½ s	3 s	3½ s	4 s	4¼ s	4½ s	10 d	8 s	13 d	12 d	14 d	20 d
Draft in the front and back rollers	1″ & 1″	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Suitable draft pinion	30–60 T	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Suitable back roller wheel	40–60 T	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Respective ratio of the above wheels		?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Twist per inch required		?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
"Draw" and length delivered by the rollers during the inward run		64″	64″	64″+ 4″	64″+ 4″	64″+ 4″	64″+ 4″	64″+ 4″	64″+ 4″	64″+ 4″	64″+ 4″	64″+ 4″	64″+ 4″	60″+ 4″	60″+ 4″	60″+ 4″	60″+ 4″
Actual revolutions of the spindles required per draw		?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Actual rate of revolutions of the rim shaft per minute required		?	?	940	940	940	940	940	940	940	940	940	940	?	750	570	570
Ditto in respect of the spindle, required		6000	6500	7500	8000	8500	9500	10,500	10,500	10,500	10,500	9500	9500	9000	9000	8700	8000

Diameter of the rim necessary	12"–22"	?	?	?	?	?	?		?	?	?	?	?	20"	?	?	?
Diameter of the tin roller pulley	10"–12"	12"	12"	12"	12"	12"	12"	12"	12"	12"	12"	11"	11"	10"	10"	10"	10"
"Gain" in inches per draw		0·6	?	?	?	3·7	?	3·0	—	—	?	?	?	4"	3"	?	4"
Revolutions of back shaft per draw		3·6	3·6	3·6	3·6	3 6	3·6	3·6	3·6	3·6	3·6	3·6	3·6	3·38	3·38	3·38	3·38
Change wheel on the rim shaft driving the train to rollers (number of teeth): this is the first driver wheel	17–30	?	?	?		?	?	?	?	?	?	?	?	?	?	?	?
Suitable first driven wheels in the train to the rollers	40–60	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Suitable second driver wheel in ditto	27–35	35	35	35	35	35	35	35	35	35	35	35	35	27	27	27	27
Suitable third driver wheel in ditto	17–20	20	20	20	20	20	20	20	20	20	20	20	20	17	17	17	17
Gain wheel: first driven wheel in the train to the back shaft, from the rollers	97–112	112	111	110	109	—	108	—	—	—	112	112	107	?	?	?	?
Second driver wheel in ditto (gain boss wheel)	25–27	25	25	25	25	—	25	—	—	—	26	26	25	?	?	?	?
Diameter of cop	$\frac{7}{8}''$–$1\frac{1}{4}''$	$1\frac{1}{4}''$	$1\frac{1}{4}''$	1·0"	$1\frac{1}{4}''$	1"	$1\frac{1}{4}''$	1"	$1\frac{1}{8}''$	$1\frac{1}{8}''$	$\frac{15}{16}''$	$1\frac{1}{8}''$	$\frac{7}{8}''$	$1\frac{1}{16}''$	$\frac{7}{8}''$	$\frac{7}{8}''$	$\frac{7}{8}''$
Builder wheel	12–60	12	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Examples in Calculating the Exercises on Page 170–1.

The following changes would be necessary to adapt the gear in Fig. 33 for the conditions stated :—

Exercise 1.—To drive the spindles at 6000 revolutions per minute, actual, with a 12-inch rim:

The calculated rate of the spindles will $= \frac{6000 \times 100}{90} = 6666$ and $\therefore$ the

Revolutions of Rim Shaft.—With the minimum and maximum sizes of driver and driven change pulleys respectively (see par. (*a*), p. 163)—

$$\text{Revolutions of the rim shaft per minute} = \frac{6666 \times \frac{3}{4} \times 12}{6 \times 12} = 834$$

Speed and Twist Changes.—The front roller, if 1 inch in diameter, and there is no gain, will be required to make $\frac{64'' \times 7}{22} = 20\frac{4}{11}$ revolutions per draw. During this movement the spindles are required to insert twist to the extent of $3{\cdot}75\sqrt{8} = 10{\cdot}6$ per inch, or $3{\cdot}75\sqrt{8} \times 64$ (inches per draw) $= 753$, actual; and therefore the calculated revolutions of the spindle per draw are $\frac{753 \times 100}{90} = 837$, or $\frac{837}{64} = 13{\cdot}1$ calculated twist per inch.

The train of gear connecting the spindle and the front roller (see pars. (*a*), (*b*), pp. 163–4) must therefore have the following value : $\frac{837}{20\frac{4}{11}} = \frac{837 \times 11}{\cdot 224} = 41{\cdot}1$.

According to the range in the change wheels given in Fig. 33 the lowest value of this train is $\frac{6{\cdot}0 \times 12 \times 40 \times 35 \times 38}{0{\cdot}75 \times 12 \times 30 \times 35 \times 20} = 20{\cdot}2$.

Hence, altering the value of any of the wheels contained in this train, to increase their ratio 20·2 to 41·1, will have the effect desired. Namely, changing the twist to 13·1 calculated.

Therefore the wheels $\frac{40\ (\text{driven})}{30\ (\text{driver})} = 1{\cdot}\dot{3}$ must be altered in value to $\frac{40}{30} \times \frac{41{\cdot}1}{20{\cdot}2}$ $= 2{\cdot}7 = \frac{54}{20}$

Therefore the required wheel on rim shaft = 20, and the speed wheel = 54.

For "**Gain**" **Wheel**, see pp. 166–7.

The **Draft** required in the rollers is that necessary to attenuate $1\frac{1}{2}^s$ to 8^s count, or $\frac{8}{1\frac{1}{2}} = \frac{16}{3} = 5\frac{1}{3}$. By assuming the draft change pinion necessary, x, the following equation is obtained :—

$$\frac{54}{x} \times \frac{130}{16} \times \frac{1}{1} = 5\tfrac{1}{3} \qquad \therefore x = \frac{54}{5\frac{1}{3}} \times \frac{130}{16} = 82$$

The range of sizes of draft pinion wheels that can be accommodated is, approximately, from 30 to 60, and on the back roller from 40 to 60. The wheel

82 is, therefore, too large, and hence it is necessary to reduce the size to within the range of accommodation. The ratio of these two wheels is $\frac{\text{driver}}{\text{driven}} = \frac{82}{54}$ or 1·52.

Hence, any of the following pairs of wheels would be suitable for the position: $\frac{47}{31}, \frac{56}{37}, \frac{59}{39}$.

Exercise 6.—In this instance the length of yarn to be wound each draw is 64 + 4 inches, and hence the twist inserted must be in accordance therewith.

$$\text{Twist per inch required in the yarn wound} = \sqrt{24} \times 3{\cdot}75 = 18{\cdot}4$$
$$\therefore \text{Twist per draw} = 68 \text{ inches} \times 18{\cdot}4 = 1250$$

According to par. (b_3), p.163, the gear should be—tracing the train from the rim shaft to the F.R.: 17 driving 45, 27 driving 35, 17 driving 38 = 1250 revolutions of rim per draw; and therefore $\frac{1250}{68} = 18{\cdot}4$ twist per inch, this being with a 12-inch rim pulley and at the rate of 7520 revolutions of the spindle per minute.

The Size of Rim.—The rate of the spindle required is 9500 revolutions per minute, actual; hence, with the rim shaft making 940 revolutions per minute, and the size of the rim x, and 10 per cent. allowed for slippage, the following equation is obtained :—

$$\frac{940 \times x \times 6}{12 \times \frac{3}{4}} = \frac{9500 \times 100}{90} = 10555$$
$$\therefore x = \frac{10555 \times 12 \times \frac{3}{4}}{940 \times 6} = 16{\cdot}85, \text{ say 17 inches}$$

The revolutions of the spindles per draw, actual = 1250

Allowing for slippage, the calculated revolutions of spindle per draw = 1390

Proof that the above is satisfactory :—

The Speed Train of Wheels.—The train connecting the rollers with the spindles must therefore have a value of $\frac{1390}{20\frac{4}{11}} = 68{\cdot}3$.

This means that the spindle must be calculated to move 68·3 revolutions per 1 of the F.R., and hence the following equation, when the speed wheel has the value x:—

$$\frac{68{\cdot}3 \times \frac{3}{4} \times 12 \times 17 \times 27 \times 17}{6 \times 17 \times x \times 35 \times 38} = 1 \qquad \therefore x = 35{\cdot}4$$

Alternative sizes of suitable wheels :—

The smallest speed wheel practicable being 40 (40–60), and the ratio required between this and the wheel on the speed shaft being $\frac{17}{35{\cdot}4}$, the following other wheels, within the range of accommodation, will give, approximately, the desired results: $\frac{23}{48}, \frac{24}{50}, \frac{25}{52}, \frac{26}{54}, \frac{\text{wheel on rim shaft}}{\text{speed wheel}}$.

The draft required in the rollers is that necessary to attenuate 3^s roving

into $24^s = \frac{24}{3} = 8$. By assuming x the draft change pinion, the following equation is obtained:—

$$\frac{54 \times 130 \times 1}{x \times 16 \times 1} = 8 \qquad \therefore x = \frac{54 \times 130}{8 \times 16} = 55, \text{ Draft pinion}$$

$$\text{Builder wheel} = \frac{12 \times \sqrt{24}}{2\sqrt{8}} + \frac{12 \times 24}{2 \times 8} = 10{\cdot}4 + 18 = \text{say } 28$$

EXERCISE 7.—The draft for 28^s W, from 3^s single roving $= \frac{28}{3} = 9\frac{1}{3}$. Assuming x the draft change pinion, and 54 the B.R.W., the following equation is obtained:—

$$\frac{54 \times 130 \times 1}{x \times 16 \times 1} = 9\tfrac{1}{3} \qquad \therefore x = \frac{54}{28} \times \frac{3 \times 130}{16} = 47, \text{ Draft pinion}$$

The size of rim necessary to obtain the rate of rotation of the spindles, 10,500 + 10 per cent. for loss, may be obtained from the following equation, when x = the size of the rim in inches:—

$$940 \times \frac{x}{12} \times \frac{6}{\frac{3}{4}} = \frac{10500 \times 100}{90} = 11680$$

$$\frac{940 \times 6}{11680 \times 12 \times \frac{3}{4}} = \frac{1}{x}$$

$$\therefore \frac{11680 \times 12 \times \frac{3}{4}}{940 \times 6} = \frac{x}{1} = 18{\cdot}65, \text{ say 19 inches, Rim}$$

The twist per inch $= \sqrt{28} \times 3{\cdot}25 = 17{\cdot}2$

Therefore the twist per draw (68 inches) $= 17{\cdot}2 \times 68$ inches $= 1170$

Assuming the front roller makes $20\frac{4}{11}$ revolutions per draw, and the speed wheel contains x teeth, the following equation contains the value of x, allowing 10 per cent. for slippage:—

$$20\tfrac{4}{11} \times \frac{38 \times 35 \times x \times 19 \times 6}{20 \times 35 \times 30 \times 12 \times \frac{3}{4}} = \frac{1170 \times 100}{90} = 1300$$

$$\therefore \frac{1300 \times 20 \times 35 \times 30 \times 12 \times \frac{3}{4}}{20\frac{4}{11} \times 38 \times 35 \times 19 \times 6} = \frac{x}{1} = 79{\cdot}7, \text{ Speed wheel}$$

This wheel being too large, a pair of wheels of suitable size may be obtained from the ratio provided by these change wheels, therefore—

$$\frac{\text{driver}}{\text{driven}}, \text{ or } \frac{30}{79{\cdot}7}, \text{ say } \frac{20}{53}$$

The gain wheels necessary to give 3 inches "gain" are—

$$3\tfrac{3}{5} \times \frac{75}{60} \times x = \frac{64 - 3}{\frac{22}{7}} \text{ revolutions of the front roller} = 19{\cdot}4$$

here x = the value of the $\frac{\text{driven}}{\text{driver}}$, change wheels

$$\therefore 3\tfrac{3}{5} \times \frac{75}{60} \times x = 19{\cdot}4 \qquad \therefore x = \frac{60 \times 19{\cdot}4}{3{\cdot}6 \times 75} = 4{\cdot}31$$

Any pair of wheels within the range of size applicable and having this ratio would suffice.

$$\therefore \frac{112}{4{\cdot}31} = \text{say } 26$$

These would give the nearest to that required.

$$\text{The builder wheel} = \frac{12 \times \sqrt{28}}{2\sqrt{8}} + \frac{12 \times 28}{2 \times 8} \times \frac{1'' \times 1''}{1\frac{1}{4}'' \times 1\frac{1}{4}''} = 20{\cdot}8, \text{ say } 21.$$

NOTE.—The differences in the size of the cop required will affect the wheel directly proportional to their areas, and therefore as their diameters² (squared).

EXERCISE 13.—The draft required to attenuate the 13-hank roving, double, to $80^s = \frac{80 \times 2}{13} = 12{\cdot}3$.

The ratio of the draft change wheels, x, is found as follows:—

$$12{\cdot}3 = \frac{130}{16} \times x \qquad \therefore \frac{12{\cdot}3 \times 16}{130} = x = 1{\cdot}514$$

$$\text{Ratio} = \frac{\text{driven}}{\text{driver}} \text{ or } \frac{\text{B.R.W.}}{\text{pinion}} = \frac{59}{39}, \text{ or } \frac{56}{37}, \text{ or } \frac{53}{35}$$

The revolutions of the rim shaft per draw—

$$\text{Twist per inch} = 3{\cdot}6\sqrt{80} = 32{\cdot}2$$

$$\text{,, } \quad \text{draw} = 32{\cdot}2 \times 68 = 2189$$

The size of rim, x, allowing for 10 per cent. for slippage—

$$= 750 \times \frac{x}{12} \times \frac{6}{\frac{3}{4}} = \frac{9000 \times 100}{90} \qquad \therefore x = \frac{10000 \times 12 \times \frac{3}{4}}{750 \times 6} = 20''$$

The speed change wheels ratio, x, assuming no pause twisting at the head, and the gain 4 inches; is found as follows:—

$$\frac{2189 \times 100}{90} \times \frac{\frac{3}{4} \times 12}{6 \times 20} \times x \times \frac{27 \times 17}{35 \times 38} = \frac{60 - 4}{\frac{22}{7}} = 17{\cdot}8 \text{ revs. of F.R. per draw}$$

$$x = \frac{17{\cdot}8 \times 90 \times 6 \times 20 \times 35 \times 38}{2189 \times 100 \times 0{\cdot}75 \times 12 \times 27 \times 17} = 0{\cdot}283$$

Therefore the only possible wheels within the ranges specified in Fig. 33 are $\frac{60}{17}$.

Gain.—The revolutions of the back shaft and front roller required per draw respectively, being 3·38 and 17·8, the following equation gives the value of x, the gain change wheel ratio:—

$$3{\cdot}38 \times \frac{75}{60} \times x = 17{\cdot}8 \qquad \therefore x = \frac{17{\cdot}8 \times 60}{3{\cdot}38 \times 75} = 4{\cdot}21$$

The pair of wheels within the range specified having the nearest to this ratio are $\frac{105}{15}$, $\frac{\text{gain}}{\text{gain boss wheel}}$.

$$\text{The builder wheel} = \frac{12\sqrt{80}}{2\sqrt{8}} + \frac{12 \times 80}{2 \times 8} \times \frac{(1\frac{1}{16})^2}{(1\frac{1}{4})^2} = 57$$

Exercise 16.—The draft required in the rollers $= \frac{100 \times 2}{20} = 10.$

The draft change wheels ratio, x, must be—

$$\tfrac{130}{16} \times x = 10$$

$$\therefore x = \frac{10 \times 16}{130} = \frac{160}{130} = 1 \cdot 23$$

Therefore the suitable draft wheels are—

$$\frac{\text{B.R.W.}}{\text{P.W.}} = \frac{48}{39}, \frac{53}{43}, \frac{54}{44}$$

$$\text{The twist per inch required} = 3 \cdot 18\sqrt{100}$$

$$\text{,, draw ,,} = 64 \times 3 \cdot 18\sqrt{100} = 2035$$

Allowing for 10 per cent. loss, the calculated revolutions of the spindles per draw required $= \frac{2035 \times 10}{9} = 2238.$

The actual revolutions per minute of the spindles required = 8000

$\therefore$,, calculated ,, ,, ,, $= \frac{8000 \times 10}{9} = 8888$

$$\text{With the size of rim required } 570 \times \frac{x}{10} \times \frac{6}{\frac{3}{4}} = 8888$$

$$\therefore x = \frac{8888 \times 10 \times \frac{3}{4}}{570 \times 6} = 19 \cdot 5 \text{ say}$$

$$\text{The revolutions of the front roller per draw required} = \frac{60'' - 4''}{\frac{22}{7}} = 17 \cdot 8$$

$$\text{The revolutions of the rim shaft per draw} = \frac{8888 \times 10 \times \frac{3}{4}}{19 \cdot 5 \times 6} = 143$$

The speed change wheels ratio, x, is therefore—

$$17 \cdot 8 \times \frac{60}{17} \times \frac{35}{27} \times x = 143 \qquad x = \frac{143 \times 17 \times 27}{17 \cdot 8 \times 60 \times 35} = 1 \cdot 755$$

Therefore any of the following pairs of wheels would be suitable :—

$$\frac{\text{speed wheel}}{\text{rim shaft wheel}} = \frac{42}{24}, \frac{44}{25}, \frac{49}{28}, \frac{51}{29}$$

Gain.—The revolutions of the back shaft and front roller required per draw, respectively, being 3·38 and 17·8, the following equation gives the value of x the gain change wheels ratio :—

$$3{\cdot}38 \times \frac{75}{60} \times x = 17{\cdot}8 \qquad \therefore x = 4{\cdot}21$$

And hence the following pair of these wheels are most suitable—

$$\frac{105}{15} = \frac{\text{gain wheel}}{\text{gain boss wheel}}$$

$$\text{The builder wheel} = \frac{12\sqrt{100}}{2\sqrt{8}} + \frac{12 \times 100}{2 \times 8} \times \frac{(\frac{7}{8})^2}{(1\frac{1}{4})^2} = 47$$

Particulars of Gearing in "Dobson's Ord." Mule.—Fig. 34 shows

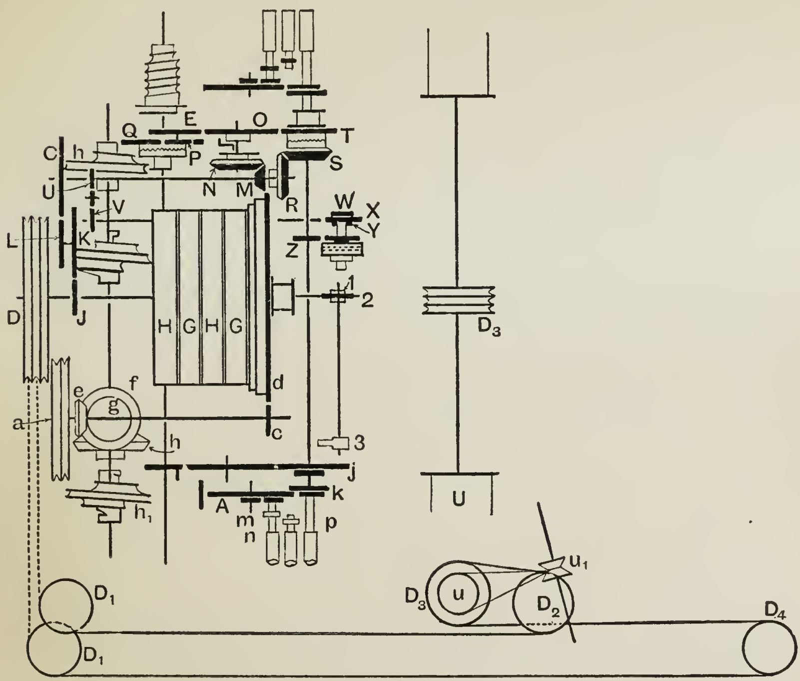

FIG. 34.

the arrangement of the gearing in mules for medium and medium fine counts as made by Dobson and Barlow.

The following are particulars of the various trains and the range in the size of the wheels shown :—

(*a*) *Train to Spindles.*—Revolutions of the rim shaft (H G) per minute from 400 to 850 per minute. Rim pulley, D, 12–22 inches; tin roller pulley, D_3, 10–12 inches; tin roller, U, 6 inches; spindle wharves, u_1, 3–4 inches.

(*b*) *Train to the Rollers.*—J, 19; K, 58; L, 30–56; C, 60–100; R, 32; S, 25.

(*c*) Roller draft gear: *k*, 20; *l*, 180; A, 30–60; *m*, 30–70.

Diameters of rollers: front, 1 inch; middle, $\frac{7}{8}$ inch; back, 1 inch.

(*d*) *Train to the Back Shaft from the Front Roller Shaft.*—T, 51–55; O, 55; E, 70–78; P, 16–20; Q, 68; M, 15; N, 55.

Revolutions of the back shaft per draw: 3·5 for 64-inch draw; 3·28 for 60-inch draw; 3·06 for 56-inch draw.

(*e*) *Train for Slow Roller Turning, sometimes called the Receding Motion.*—U, 20; V, 40; W, 1; X, 30; Y, 24; Z, 24.

Train for Roller Delivery during the Inward Run.—*i*, 14–17; *j*, 40.

Taking-in and Backing-off Motion Gear.—*a*, 14 inches; *c*, 17; *f*, 24; *g*, 14; *h*, 40; *c*, 10; *d*, 73.

Taking-in motion shaft, *a*: 170–350 per minute.

Revolutions of taking-in motion shaft *d* per 64-inch draw, 3.

Building or Shaper Motion.—Wheel, 12–70, and various pitch of screws.

Twist Wheel.—40–120.

Exercises.—Ascertain the following, from the particulars contained in Fig. 34:—

1. The range in the rates per minute at which the spindles may be driven.
2. The range in the twist that may be inserted in the yarn.
3. The range in the draft.
4. The range in the counts, twist and weft, which the machine is adapted for in the respect of twisting with the normal twist constants.
5. The ratio in the movement of the carriage before and under the influence of the jacking motion, assuming that during the former movement the drawing-out band is on the full-sized portion of the scroll; and at the termination of the latter movement, on the half-sized portion of that part.
6. The ratio of the roller and carriage movements during twisting at the head and when in ordinary action.
7. The ratio in the rates of the spindles during spinning and when backing-off.
8. The time, in seconds, taken to move the carriage-in, at the slowest and quickest rates.
9. The length, in inches, delivered by the rollers during the inward run.

Answers—
1. 3200–14,960.
2. 7·28–44·5.
3. 4·5–21.
4. 4·0^s twist, 5^s·25 weft to 210^s weft, 152^s twist.

In the above calculation, the calculated twist is as obtained without the use of twist wheels. By using twist wheels, the twist may be extended to suffice for all practical requirements, taking the above as representing $\frac{5}{8}$ of the possible twist then the range could be extended to 78·4 turns per inch.

Example in respect of Exercise 5.—The difference in the train pulling out the carriage during jacking: R, S, being in abeyance, and the motion is obtained through M. N.

The train prior to jacking, from the side shaft, is R, S, T, O, E, P, Q; and during jacking M, N, O, E, P, Q.

The difference in these values are: $\frac{32}{25}$, $\frac{55}{70}$, $\frac{16}{68}$ and $\frac{15}{55}$, $\frac{55}{70}$, $\frac{16}{68}$, or, $\frac{32}{25}$ and $\frac{15}{55}$ respectively, or 3·5 : 1.

This is the ratio, when jacking is proceeding, with the drawing-out band wound upon the full-sized portion of the scroll. As the scroll portion is gradually brought into action this ratio increases. When the half-size portion is acting, the reduction in the rate of the movement has attained $3{\cdot}5 \times 2 = \frac{1}{7}$, of the normal rate.

Example in respect of Exercise 6.—The difference in the trains driving the rollers whilst the carriage is at rest, and twisting "at the head," is as follows :—

The wheel train RS is in abeyance, and motion is obtained through train U, V, W, X, Y, Z, and therefore—

The values of these trains are respectively $\frac{32}{25}$ and $\frac{20}{40}$, $\frac{1}{30}$, $\frac{24}{24}$, or as 77 : 1.

Example in respect of Exercise 7.—The difference in driving the spindles during spinning and "backing-off" are respectively—

Lowest rate of the rim shaft during spinning, 400

" " " "backing-off," $\frac{170 \times 10}{73}$

and therefore the rate of the spindle during the latter period is $\frac{400}{170 \times \frac{10}{73}}$ times less than during the former period = slightly more than $\frac{1}{17}$.

Example in respect of Exercise 8.—Assuming the taking-in scroll shaft makes 3 revolutions per draw of 62 inches, the time in seconds taken to draw the carriage in, is—

$$\text{lowest rate } \frac{3}{170 \times \frac{17}{24} \times \frac{14}{40}} \times 60 = 4{\cdot}27 \text{ seconds}$$

or, average rate, 14½ inches per second.

Example in respect of Exercise 9.—Assuming the back shaft makes 3·39 revolutions during the drawing in of the carriage and the 17 wheel is in use on the back shaft, the length delivered, equals—

$$3{\cdot}39 \times \frac{17}{40} \times \frac{1'' \times 22}{7} = 4{\cdot}52 \text{ inches}$$

EXERCISES.—Ascertain the production in hanks per 55 hours, without allowances for stoppages; and the various change wheels necessary to adapt the gearing, as contained in Fig. 34, for the undermentioned counts and conditions of production.

Allowances: For slippage, in driving the spindles from the rim shaft, 10 per cent.; draw, 60 + 4½ inches, the latter delivered during the inward run; backing-off and run-in to occupy 5 seconds; loss of speed due to changes, 10 per cent.

1. 60 W. from 10-hank double roving, Egyptian: actual speeds of rim and spindles, 850 and 10,000 revolutions per minute; gain, 1 inch; jacking, 1 inch; 5 per cent. of twist being inserted after jacking.
2. 60 T. from 12-hank double roving, Egyptian: rim and spindle speeds, 840 and 10,000 revolutions per minute actual; gain, 1½ inch; jacking, 1 inch; 12 per cent. of twisting after jacking.
3. 80 W. from 14-hank double roving, Egyptian: rim and spindle speeds, 840 and 9000 revolutions per minute actual; gain, 2 inches; jacking, 1½ inch; 8 per cent. of twisting after jacking.
4. 80 T. from 16-hank double roving, Egyptian: rim and spindle speeds, 840 and 9500 revolutions per minute actual; gain, 2 inches; jacking, 2 inches; 12½ per cent. of twisting after jacking.
5. 94 W. from 16-hank double roving, Egyptian: rim and spindle speeds, 840 and 8700 revolutions per minute actual; gain, 2 inches; jacking, 2 inches; 10 per cent. of twisting after jacking.
6. 90 T. from 16-hank double roving, Egyptian: rim and spindle speeds, 840 and 8700 revolutions per minute actual; gain, 1 inch; jacking, 2½ inches; 12½ per cent. of twisting after jacking.

Example of working Exercise 1.—The spindle speed will be attained by using a rim and tin roller pulleys of the following diameter:—

Let x = the spindle speed change ratio;

$$\text{then } 850 \times x \times \frac{6}{\frac{3}{4}} = \frac{10000 \times 10}{9} \quad \therefore x = \tfrac{1000}{612} = 1{\cdot}634$$

∴ 18 inches R.P. and 11 inches T.R.P. or, others giving this ratio.

The revolutions of the rim shaft per draw must be—

$$\frac{60 + 4\tfrac{1}{2} \times 3{\cdot}18\sqrt{60}}{\frac{18}{11} \times \frac{6}{\frac{3}{4}} \times \frac{90}{100}} = 135$$

The speed change gear must be arranged to obtain the delivery of 60 − 2 inches whilst the back shaft is moving the carriage out 59 inches, and therefore the $\frac{3{\cdot}28 \times 59}{60}$ revolutions of the back shaft are required in the same period. During this movement the spindles are required to insert twist in accordance with the state specified, *i.e.* 100 per cent. − 5 per cent. − x per cent. twisting during jacking. During "jacking" the carriage is assumed to move at $\frac{2}{7}$ the normal rate, and therefore requires a period equal to that required to move the carriage $3\frac{1}{2}$ inches at the latter rate. Hence, 95 per cent. of the twisting equals the period required for $59 + 3\frac{1}{2}$ inches of movement at the normal rate, and therefore the revolutions of the rim, during the above 59 inches, must be—

$$\frac{95\% \times 59}{62\frac{1}{2}} = 89\tfrac{1}{2} \text{ per cent. of } 135 = 120 \text{ revolutions of rim}$$

During the run out of the carriage, the front roller is required to deliver 58 inches, and therefore it must make—

$$\frac{58}{1 \times \frac{22}{7}} = 18{\cdot}43 \text{ revolutions}$$

The speed change gear ratio (x) is therefore—

$$120 \times \tfrac{19}{58} \times x \times \tfrac{32}{25} = 18{\cdot}43 \quad \therefore \quad x = \frac{18{\cdot}43 \times 58 \times 25}{120 \times 19 \times 32} = 0{\cdot}366$$

The speed change wheels, within the range having this value, are—

$$\frac{\text{driver}}{\text{driven}}\ \frac{34}{101},\ \frac{35}{104},\ \frac{36}{107},\ \frac{37}{110},\ \frac{38}{113},\ \frac{39}{116},\ \frac{40}{119}$$

The "gain" change gear must be arranged to impart $\frac{3{\cdot}28 \times 59}{60}$ revolutions to the back shaft per 18·43 revolutions of the front roller, before jacking commences. Therefore the gain change wheel ratio (x) must be—

$$18{\cdot}43 \times \frac{55}{68} \times x = \frac{3{\cdot}28 \times 59}{60} \qquad \therefore x = \frac{3{\cdot}28 \times 59 \times 68}{12{\cdot}43 \times 60 \times 55} = 0{\cdot}216$$

The change wheels nearest to this value are—

$$\frac{\text{driver}}{\text{driven}}\ \frac{16}{74}$$

The draft and draft change wheels.—A 10-hank double rove would necessitate a draft of $\frac{60{\cdot}0}{\frac{10}{2}} = 12$, if the draft due to gain and jacking is neglected.

Taking the latter into account, it would be—

$$\frac{12 \times 62\frac{1}{2}}{64\frac{1}{2}} = 11{\cdot}6$$

The draft change wheel ratio (x) to give the latter draft must be—

$$\tfrac{180}{20} \times x = 11{\cdot}6 \qquad \therefore\ x = \frac{11{\cdot}6 \times 20}{180} = 1{\cdot}29$$

The draft change wheels, within the range specified, containing this value—

$$\frac{\text{driven}}{\text{driver}} = \frac{62}{48},\ \frac{58}{45},\ \frac{53}{41},\ \frac{49}{38}$$

Twist wheels are necessary when the rim shaft is required to rotate a definite amount after the carriage has reached the "head." Usually it is most convenient to arrange them to make one or two revolutions per draw, and therefore, in this instance, since 135 is not available, $\frac{135}{2}$, say 68.

$$\text{Time per draw} = \frac{135}{840} \times \frac{60 \times 100}{95} + 5 = 10{\cdot}15+5 = 15{\cdot}15 \text{ secs.}$$

$$\text{Hanks per spindle per week} = \frac{60 \times 60 \times 55 \times 64\frac{1}{2}}{15{\cdot}15 \times 36 \times 840} = 27{\cdot}8$$

Example of working Exercise 6.—The required speed of spindle will be obtained when the change pulleys in the gear from the rim to the spindles have the ratio x in the following equation :—

$$840 \times x \times \frac{6}{\frac{3}{4}} = \frac{8700 \times 10}{9} = 9666$$

$$\therefore\ x = 1{\cdot}44$$

$$\therefore\ \text{ratio} = \frac{\text{rim}}{\text{T.R.P.}} = \tfrac{16}{11} \text{ nearest}$$

Therefore the revolutions of the rim per draw, if the latter are adopted—

$$= \frac{60 + 4\frac{1}{2} \times 3{\cdot}6 \times \sqrt{90} \times 100}{\frac{16}{11} \times \frac{6}{\frac{3}{4}} \times 90} = 210$$

NOTE.—The $\frac{100}{90}$ is the slippage.

The speed change gear must be arranged to obtain the delivery of $60 - 3\frac{1}{2}$ inches whilst the carriage moves $57\frac{1}{2}$ inches outward, and therefore the back shaft makes $\frac{3{\cdot}28 \times 57\frac{1}{2}''}{60} = 3{\cdot}14$ revolutions during this roller movement. The spindles are required to insert twist amounting to the following, in the same period, and hence $\frac{210 \times 87\frac{1}{2} \times 57\frac{1}{2}}{100 \times 66\frac{1}{4}}$ revolutions of rim per draw $= 159$.

$\frac{57\frac{1}{2}}{66\frac{1}{4}}$ is the fraction of $87\frac{1}{2}$ per cent. of 210 revolutions, during which time the carriage and rollers are moving at the normal rate. This is ascertained from the rate of jacking proceeding at $\frac{1}{3\frac{1}{2}}$ slower than the normal rate, the jacking rate being from $\frac{1}{3\frac{1}{2}}$ to $\frac{1}{7}$ the normal depending upon the extent of the scrolled portion of the drawing-out barrels, on the back shaft, in action.

The front roller is therefore required to make $\frac{56\frac{1}{2}}{1 \times \frac{22}{7}}$ revolutions prior to jacking, and whilst the rim shaft makes 159 revolutions, and hence the speed change wheels ratio, x, is contained in the following equation :—

$$159 \times \frac{19}{58} \times x \times \frac{32}{25} = \frac{56\frac{1}{2}}{1 \times \frac{22}{7}} = 18$$

$$\therefore x = \frac{18 \times 58 \times 25}{159 \times 19 \times 32} = 0{\cdot}27$$

The speed change wheels nearest to this value are $\frac{30}{111} \frac{\text{driver}}{\text{driven}}$.

The 111 wheel is beyond the range stated on the figure, but in this case 110 would probably suffice; if not, it would then be necessary to make an alteration in some other wheel of this train. For values lower than 0·27, the most convenient alteration is R.

The "Gain" Change Wheels must be arranged to give 3·14 revolutions to the back shaft whilst the rollers make 18; therefore the gain change wheels ratio, x, must be—

$$18 \times \tfrac{55}{68} \times x = 3{\cdot}14 \qquad \therefore x = \frac{3{\cdot}14 \times 68}{18 \times 55} = 0{\cdot}216$$

The "gain" change wheels having this ratio and within the ranges specified are: $\frac{16}{74}$.

The Draft and Draft Change Wheels.—A 16-hank double rove will necessitate a draft of $\frac{90}{\frac{16}{2}} = 11\frac{1}{4}$, if allowance is not made for "gaining" and jacking. Allowing for the latter, it would be—

$$11\tfrac{1}{4} \times \frac{61}{64\frac{1}{2}} = 10{\cdot}63$$

The draft change wheel ratio, x, is contained in the equation—

$$\tfrac{180}{20} \times x = 10{\cdot}63 \qquad \therefore x = 1{\cdot}18$$

Therefore the draft change wheels suitable are—

$$\frac{\text{driven}}{\text{driver}} = \frac{53}{45}, \frac{59}{50}, \frac{65}{55}, \frac{66}{56}$$

$$\text{The time per draw in seconds} = \frac{210 \times 60 \times 100}{840 \times 1 \times 90} + 5 = 21{\cdot}7$$

$$\text{The hanks per spindle per week} = \frac{55 \times 60 \times 60 \times 64\frac{1}{2}}{21{\cdot}7 \times 36 \times 840} = 19{\cdot}5$$

Mule Calculations.—Figs. 36 and 37 show the gearing as in Platt's mules. The following examples are taken from those figures.

Motor drum, 800 revolutions and 11 inches diameter. Line shaft drum driven from the motor, 38 inches diameter; for driving the mule, 28 inches. Counter shaft drums: driven, 18; driver, 24; grooved pulley for T-up motion, 12 inches.

The revolutions of back shaft for $62\frac{1}{2}$-inch draw $= 3\frac{4}{5}$
" " " 60 " $= 3{\cdot}65$
" " " $58\frac{1}{2}$ " $= 3{\cdot}56$

Alterations for counts 100s from double 18 hank *Sea Islands Rove*, assuming the present speed of spindle suitable.

The present speed of spindle

$$= 800 \times \frac{11 \times 28 \times 24 \times 16 \times 6}{38 \times 18 \times 16 \times 11 \times \frac{3}{4}} = 6287{\cdot}7 \text{ revolutions per minute}$$

Twist constant $= 3{\cdot}6$
" per inch $= 36$

Twist per draw of 62″ put up, *i.e.* $58\frac{1}{2}'' + 3\frac{1}{2}'' = 62'' \times \sqrt{100} \times 3{\cdot}6 = 2232$

The revolutions of the rim must be such as will give 2232 revolutions of spindle per draw.

Assuming a loss of 5 per cent. in transmitting the motion to the spindle from the rim shaft, then the revolutions of the rim shaft per draw should be—

$$\frac{2232 \times 100 \times 11 \times 0{\cdot}75}{95 \times 16 \times 6} = \text{say } 202$$

The duty of the twist wheel is to control the revolutions per draw of the rim shaft. In this case the twist wheel divided by 2 equals the revolutions of the rim shaft.

$$\therefore \tfrac{202}{2} = \text{twist wheel} = 101$$

If there were no gain between the movement of the carriage as compared with the length delivered by the front roller, then the rollers must deliver, during the outward run of the carriage, $58\frac{1}{2}$ inches, and therefore the front roller must make—

$$\frac{58\frac{1}{2}}{\frac{17}{16} \times \frac{22}{7}} = 17{\cdot}518 \text{ revolutions, say } 17{\cdot}52$$

The present gear would deliver—

$$202 \times \frac{21 \times 60 \times 15}{70 \times 60 \times 30} = 30{\cdot}3 \text{ revolutions of front roller instead of } 17{\cdot}52$$

Therefore if the change be made at the speed wheel, a $\dfrac{60 \times 30{\cdot}3}{17{\cdot}52} = 104$ wheel would be necessary.

Such a large wheel would probably be impracticable. Usually the driver of the speed wheel is constituted a change wheel, in which case the extent of the difference in the change practicable, in the speed wheel, and that required, would be possible at the driver wheel.

Assuming that up to 90 are the available sizes of speed wheels, then the speed wheel driver would need to contain—

$$\frac{60 \times 90}{104} = 52 \text{ teeth}$$

N.B.—In such a case it would be unnecessary to use the twist wheel, as the fact of the carriage getting out to the head would control the revolutions of the rim, but less accurately.

No Gain.—The gain wheel and its train controls the ratio in the movement of the carriage relative to the spindle. The rollers must necessarily deliver $58\frac{1}{2}$ inches, and the carriage must move that amount.

The movement of the back shaft in drawing the carriage out $62\frac{1}{2}$-inch draw is given at $3\frac{4}{5}$ revolutions. Therefore, for $58\frac{1}{2}$-inch, proportional movement will be required, or $\frac{3\frac{4}{5} \times 58\frac{1}{2}}{62\frac{1}{2}} = 3{\cdot}56$, instead of 3·8.

Should this be the case, then the front roller must make $\frac{58\frac{1}{2}}{\frac{17}{16} \times \frac{22}{7}}$ revolutions, whilst the back shaft makes 3·56 revolutions; therefore the revolutions of the front roller = 17·52.

Note.—Variations in the tension and size of drawing-out bands will cause variations in the revolutions of the back shaft per draw.

With the present gear the revolutions of the front roller per 3·56 revolutions of the back shaft, are (see p. 192)—

$$3{\cdot}56 = \frac{\left(\frac{\text{revolutions of F.R.} \times 20}{2 \times 60}\right) + \left(\frac{\text{revolutions of F.R.} \times 40}{2 \times 40}\right)}{\frac{60}{36} \times \frac{90}{45}}$$

$$\therefore\ 3{\cdot}56 = \frac{\left(\frac{\text{revolutions of F.R.}}{6} + \frac{\text{revolutions of F.R.}}{2}\right)36 \times 45}{60 \times 90}$$

$$\therefore\ 3{\cdot}56 = \left(\frac{\text{revolutions of F.R.}}{6} + \frac{3\text{ revolutions of F.R.}}{6}\right)\frac{6}{20}$$

$$\therefore\ 3{\cdot}56 = \frac{4x}{6} \times \frac{6}{20} = \frac{4x}{20} = \frac{x}{5}$$

$$\therefore\ 3{\cdot}56 \times 5 = x$$

$$\therefore\ x = 17{\cdot}80 \text{ revolutions of F.R.}$$

The gain wheel must therefore be altered to give 17·52 revolutions, and therefore—

$$\therefore\ 3{\cdot}56 = \frac{\left(\frac{17{\cdot}52 \times 20}{2 \times 60}\right) + \left(\frac{17{\cdot}52 \times 40}{2 \times 40}\right)}{\frac{60}{36} \times \frac{\text{G.W.}}{45}}$$

$$\therefore\ 3{\cdot}56 = \frac{\left(\frac{17{\cdot}52}{6} + \frac{17{\cdot}52}{2}\right)36 \times 45}{60 \times \text{G.W.}}$$

$$\therefore 3{\cdot}56 = \frac{\left(\frac{17{\cdot}52}{6} + \frac{3 \times 17{\cdot}52}{6}\right) 36 \times 45}{60 \times \text{G.W.}}$$

$$\therefore 3{\cdot}56 = \frac{70{\cdot}08}{6} \times \frac{36}{60} \times \frac{45}{\text{G.W.}}$$

$$\therefore \frac{3{\cdot}56 \times 6 \times 60}{70{\cdot}08 \times 36 \times 45} = \frac{1}{\text{G.W.}}$$

$$\therefore \frac{70{\cdot}08 \times 36 \times 45}{3{\cdot}56 \times 6 \times 60} = \frac{\text{G.W.}}{1} = \frac{70{\cdot}08 \times 9}{3{\cdot}56 \times 2}$$

$$\therefore \text{G.W.} = \frac{630{\cdot}72}{7{\cdot}12} = 88{\cdot}5, \text{ say } 89 \text{ or } 88$$

"*Gain*" *Changes.*—The 36 gain boss wheel combined with an 88·5, gives, according to previous calculations, a delivery by front roller of 58·5 inches. Taking this as a basis, the amount, in inches, delivered by the front roller per 3·56 revolutions of the back shaft, with various other sizes of gain wheels, is as follows :—

Gain boss wheel.	Gain wheel.		Variations in count resulting.
36	88	$\frac{58\frac{1}{2} \times 88{\cdot}5}{88} = 58{\cdot}83$	99·5
36	87	$\frac{58{\cdot}5 \times 88{\cdot}5}{87} = 59{\cdot}5$	98·4
36	86	$\frac{58{\cdot}5 \times 88{\cdot}5}{86} = 60{\cdot}2$	97·2
36	85	$\frac{58{\cdot}5 \times 88{\cdot}5}{85} = 60{\cdot}9$	96·0
36	89	$\frac{58{\cdot}5 \times 88{\cdot}5}{89} = 58{\cdot}17$	100·5
36	90	$\frac{58{\cdot}5 \times 88{\cdot}5}{90} = 57{\cdot}52$	101·6
36	91	$\frac{58{\cdot}5 \times 88{\cdot}5}{91} = 56{\cdot}89$	102·8
36	92	$\frac{58{\cdot}5 \times 88{\cdot}5}{92} = 56{\cdot}26$	104·0
36	90	$\frac{58{\cdot}5 \times 88{\cdot}5}{90} = 57{\cdot}52$	101·6
35	90	$\frac{57{\cdot}52 \times 36}{35} = 59{\cdot}16$	99·0
34	90	$\frac{57{\cdot}52 \times 36}{34} = 60{\cdot}9$	96·0
37	90	$\frac{57{\cdot}52 \times 36}{37} = 55{\cdot}9$	104·6
36	91	56·89	102·8

Gain boss wheel.	Gain wheel.		Variations in count resulting.
35	91	$\frac{56{\cdot}89 \times 36}{35} = 58{\cdot}31$	100·5
34	91	$\frac{56{\cdot}89 \times 36}{34} = 60{\cdot}02$	97·2
37	91	$\frac{56{\cdot}89 \times 36}{37} = 55{\cdot}35$	105 8
36	89	58·17 − 0·23 (gain)	100·6
35	89	59·83 + 1·33 „	97·8
34	89	61·32 + 2·82 „	95·4
37	89	56·6 − 1·9 „	103·3
36	88	58·83 + 0·33 „	99·4
35	88	60·51 + 1·01 „	96·7
37	88	57·24 − 1·26 „	102·0

The effect of gain on the counts of the yarn spun (see right-hand column).

The Roller Draft Wheel.—The draft necessary to attenuate two ends of 18ˢ rove, so that it is delivered by the F.R. 100ˢ count, must be—

$$\frac{100^s}{\frac{18}{2}} = 11\tfrac{1}{9}, \text{ or } \tfrac{100}{9}$$

The ratio in the surface movements of the front and back rollers respectively, must therefore be 100 : 9. With the diameters of those two parts alike, and the draft wheels as given, then the pinion wheel (x) would need to be—

$$\frac{54}{x} \times \frac{140}{16} = \frac{100}{9}, \text{ or } \frac{54 \times 140}{15} = \frac{100x}{9}$$

$$\therefore \frac{54 \times 140 \times 9}{100 \times 16} = x = 42{\cdot}5$$

Hence, the wheel used must either be 42 or 43; the count in these instances would be 101·1 or 98·8. If the exact count was required, it would be necessary to employ a pair of wheels having a ratio of 7875 : 10,000.

Draft Wheels.—Other pairs of wheels, giving a close approximate to $\frac{10000}{7875}$, are—

B.R.W. =	80	75	70	66	61	56	52	47
Pinion =	63	59	55	52	48	44	41	37
Count =	100·0	100·1	100·2	99·95	100·0	100·2	99 88	100 0

Exercise 1.—Assuming the spindle speed 6287 revolutions per minute is too slow, and that it is required to be 7073, what changes would be necessary ?—

(1) To obtain the desired spindle speed.

The readiest way is by increasing the size of the rim—

$$\frac{16 \times 7073}{6287} = 18\text{-inch rim}$$

(2) To obtain the right speed of the carriage and rollers relative to the spindles, it will be necessary to change the speed wheel.

Speed Wheel.—If 90 × 52 constitute the driven and driver, change wheels, the speeding of the spindles means that twisting takes place quicker, and therefore the rollers must be made to deliver quicker in like proportion.

$$\therefore \frac{90 \times 16}{18} = \frac{720}{9} = 80 \text{ speed wheel}$$

The rate of the production would be the time taken to twist 62 inches of yarn, after allowing 5 per cent. for loss in transmission, with the spindle making 6287 revolutions per minute.

$$\text{The time in seconds taken to twist} = \frac{22 \times 32 \times 100 \times 60}{95 \times 6 \times 287} = 22{\cdot}418$$

$$\text{The time in seconds taken to backing-off and run in} = 4{\cdot}5$$

$$\text{Time per draw} = 26{\cdot}918$$

The production after changing, *i.e.* revolutions of spindles to 7074 instead of 6287—

$$\text{Time twisting} = \frac{22{\cdot}418 \times 16}{18} = 19{\cdot}927 \text{ secs.}$$

$$\text{Time twisting backing-off and run in} = 4{\cdot}5$$

$$\text{Total time} = 24{\cdot}427$$

Production in hanks per week of 55 hours, in case of 18-inch rim—

$$\frac{60 \times 60 \times 55 \times 62''}{24{\cdot}427 \times 36 \times 840} = 16{\cdot}61 \text{ hanks per spindle}$$

Production in case of 16-inch rim: when the rate of spindle in revolutions per minute with 18-inch rim is—

$$800 \times \frac{11 \times 28 \times 24 \times 18 \times 6}{38 \times 18 \times 16 \times 11 \times \frac{3}{4}} = 7074$$

and—

$$\frac{60 \times 60 \times 55 \times 62''}{26{\cdot}918 \times 36 \times 840} = \left\{\begin{array}{l}\text{production in hanks with 16-inch rim on} \\ \quad\text{and spindle revolving 6287}\end{array}\right.$$
$$= 15{\cdot}08$$

Exercise 2.—A mule making 50^s T. has the following change wheels: Draft pinion, 40; rim, 18 inches; speed, 80; builder, 50. What changes in these would alter the counts to 36^s with—

(*a*) The speed of spindles unaltered?
(*b*) ,, ,, increased $\frac{1}{6}$?

Answers—

	(*a*)	(*b*)
Draft pinion	56	56
Speed	68	58
Rim	—	21
Builder[1]	47	47

[1] Rule given on p. 168 is here used.

Exercise 3.—A mule containing 1000 spindles and spinning 48^s, the draw being 62+4 inches, and 1100 draws are made in forming a set of cops. Find the weight of the set of cops, allowing $2\frac{1}{2}$ per cent. for breakages. *Ans.* 48 8 lbs.

Exercise 4.—The carriage in a mule, producing 46^s W., is known to move 6 per cent. slower than the front roller, single 6-hank rove being used. Find the draft required in the rollers. *Ans.* 8·17.

Exercise 5.—A mule completes 5 draws of 64 + 4 inches each in 68 seconds when spinning 40^s T. The time occupied in backing-off and winding is $4\frac{1}{4}$ seconds. What will be the calculated and maximum actual rate of revolutions of the spindles, assuming the slippage and loss of time, due to reversing, is known to be 25 per cent.? Take the twist standard for American cotton.

Answer.

$$\text{Time per draw} = \frac{68 - (5 \times 4\frac{1}{4})}{5} = \frac{46\frac{3}{4}}{5}$$
$$= 9{\cdot}35 \text{ seconds}$$

$$\text{Twist and actual revolutions of spindle per draw} = 3{\cdot}75\sqrt{40} \times 68 = 1612$$

$$\text{Calculated revolutions of the spindle per draw} = 3{\cdot}75\sqrt{40} \times 68 \times \tfrac{100}{75} = 2150$$

$$\left.\begin{array}{l}\text{Actual maximum rate of revolutions of spindle}\\ \text{per minute}\end{array}\right\} = \frac{3{\cdot}75\sqrt{40} \times 68 \times 60}{9{\cdot}35} = 10620$$

$$\left.\begin{array}{l}\text{Calculated rate of revolutions of spindle per}\\ \text{minute}\end{array}\right\} = \frac{10620 \times 100}{75} = 13720$$

Exercise 6.—What would be the production in hanks and pounds, per week of $55\frac{1}{2}$ hours, per spindle, and per mule of 1200 spindles, when the following allowances are made: 8 minutes per doff; $9\frac{1}{2}$ hours for cleaning; $2\frac{1}{2}$ per cent. for other stoppages, the cops weighing at the rate of 10 per pound?

Required: the twist per inch minus time per draw, and the production in hanks and ounces per spindle, per $55\frac{1}{2}$ hours, in a mule making cops that weigh 10 per pound, and working under the following conditions: Nett time worked, 53 hours; allow $2\frac{1}{2}$ per cent. for breakages; for doffing, 8 minutes per doff; counts, 120^s W. from combed special Egyptian cotton, (twist constant, 3·18). Spindles working at two rates of speed—first, 5880, and second, 9000 revolutions per minute. Five-eighths of the twist only is put in at first speed. The backing-off and run in occupies $5\frac{1}{2}$ seconds, and the length of the draw is $58\frac{1}{2} + 3\frac{1}{2}$ inches.

Answer—

$$\text{Twist per inch} = 3{\cdot}18\sqrt{120}$$

$$\text{Twist per draw} = 3{\cdot}18\sqrt{120} \times 62 = 2160$$

$$\text{Time per draw in seconds} = \frac{2160 \times 5 \times 60}{5380 \times 8} \text{ secs.} + \frac{2160 \times 3 \times 60}{9000 \times 8 \times 1} + 5\tfrac{1}{2}$$
$$= 13{\cdot}8 + 5{\cdot}4 + 5\tfrac{1}{2} = 24{\cdot}7$$

$$\text{Draws per doff} = \frac{1}{10} \times \frac{120 \times 840 \times 36}{62}$$

$$\left.\begin{array}{l}\text{Time per doff, including doffing,}\\ \text{in minutes}\end{array}\right\} = \frac{1}{10} \times \frac{120 \times 840 \times 36}{62} \times \frac{24{\cdot}7}{60 \times 60} + \frac{8}{60} \text{ hrs.}$$

$$= 40{\cdot}2 + 0{\cdot}133$$

$$\text{Doff per week} = \frac{53 \times 60 \times \frac{97\frac{1}{2}}{100}}{\frac{10}{16} \times \frac{120 \times 840 \times 36 \times 24{\cdot}7}{62 \times 60 \times 60} + 8} = 1{\cdot}22$$

$$\text{Weight per week in ounces} = 1{\cdot}22 \times \tfrac{16}{10} = 1{\cdot}95$$

$$\text{Hanks per week} = \frac{1{\cdot}95}{16} \times \frac{120}{1} = 14{\cdot}62$$

Dobson Double Speed and Hastening Motion.—Fig. 35 shows the arrangement in Dobson and Barlow's fine mules for driving the spindles at two speeds.

A and B are drums of different size on the line shaft; these are connected to the counter shaft by belts under control of

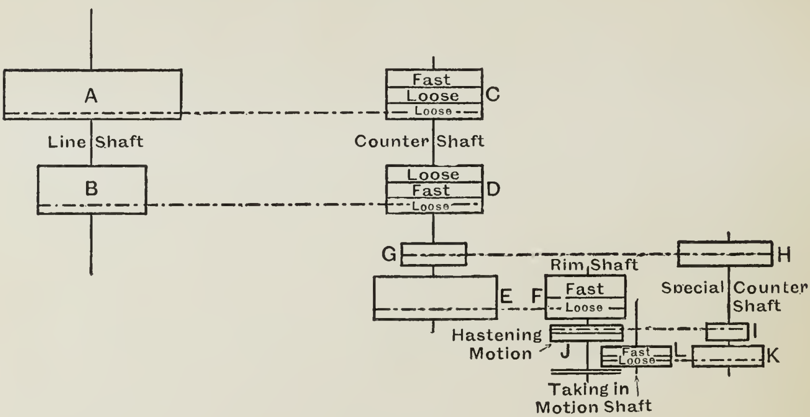

Fig. 35.

forks attached to the same bar. The stop rod, operating the straps, is notched to occupy the three positions as follows—

(1) Machine stopped; (2) first speed, B strap driving; (3) second speed, A strap driving.

This rod is operated in its second and third movements by the movement outward and inward of the carriage. The speed may be changed from the second to the third at any point in the outward run of the carriage, by adjustments.

The special counter shaft has provision for driving the taking-in motion shaft and also for driving the rim shaft. The former has been introduced to displace the friction clutch, driving the taking-in movement, with the view to obtaining smoother action. The latter is for driving the rim shaft at the closing stages of each draw, and to secure more reliable move-

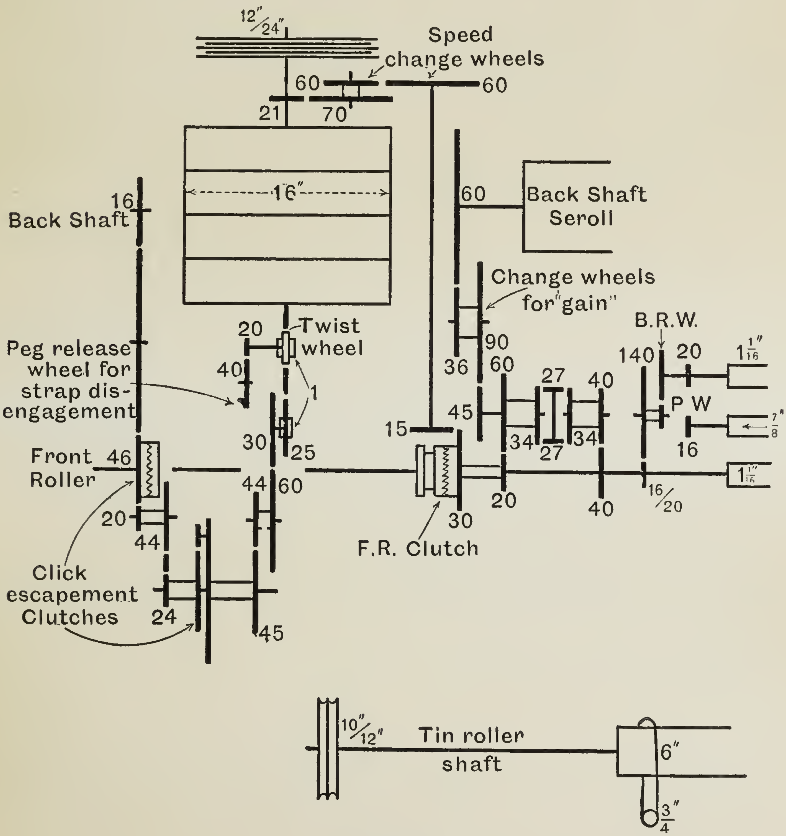

Fig. 36.

ment of the spindles during that period and extending during the unlocking of the fallers, thereby controlling the coils wound upon the bare spindle. This latter action is that commonly attributed to motions described as "hastening motions."

Platt Bros. Jacking Motion.—Figs. 36 and 37 show a plan of

that motion. m (60 – 40) and a (40 – 34) are compound wheels loose on the spindle NX, and they are driven from M and A on the front roller. M is loose on the front roller spindle, whilst A is fastened to it. Movement of NX is therefore obtained from A and M, one-half being expended in turning the wheels with 27 teeth, upon their axes, and causing them to roll upon the two 34. Thus one-half of any motion contributed to a or m passes to the T arms of NX. In calculating, the formula is—

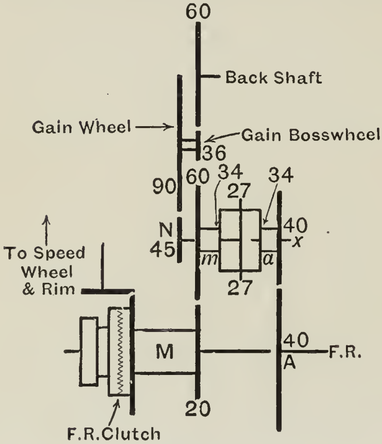

FIG. 37.

$$N = \frac{At_1}{2} + \frac{Mt_2}{2}$$

$$t_1 = \frac{40 \times 34}{40 \times 34}$$

$$t_2 = \frac{20 \times 34}{60 \times 34}$$

Thus, with the front roller clutch closed and making 100 revolutions per minute, the rate of the back shaft would be—

$$\frac{100t_1}{2} + \frac{100t_2}{2}\left(\frac{45 \times 36}{90 \times 60}\right) = \left(\frac{100 \times 1}{2} + \frac{100 \times \frac{1}{3}}{2}\right)\frac{1}{2} \times \frac{3}{5}$$
$$= (66\tfrac{2}{3})\tfrac{3}{10} = 20 \text{ revs. per minute}$$

If the front roller clutch was opened, then the rate would be—

$$\frac{100t_2}{2}\left(\frac{45 \times 36}{90 \times 60}\right) = \frac{100 \times \frac{1}{3}}{2} \times \frac{3}{10} = 5 \text{ revolutions per minute}$$

The rate of the carriage during the jacking is thus one-fourth the normal, and in addition that due to the size of the portion of the back shaft scroll in action.

To find the revolutions of the front roller when the revolutions of the back shaft are $3\frac{4}{5}$ per draw of $62\frac{1}{2}$-inch draw:

Let x = revolutions of front roller. Then—

$$\left(\frac{x \times 40 \times 34}{2 \times 40 \times 34} + \frac{x \times 20}{2 \times 60}\right)\frac{45 \times 36}{90 \times 60} = 3\tfrac{4}{5}$$

$$\therefore \left(\frac{x}{2} + \frac{x}{6}\right)\frac{3}{10} = 3\tfrac{4}{5}\,;\quad \frac{4x}{6} = \frac{19 \times 10}{5 \times 3}\,;\quad x = \frac{190 \times 6}{15 \times 4}$$

$$\therefore x = \tfrac{76}{4} = 19 \text{ revolutions of front roller}$$

In mules not arranged with this motion, the gain wheel is driven by a wheel on the front roller.

In Trelfall's Jacking Motion (Fig. 38), the right and left clutch wheels, 130 teeth, are loose upon the shaft; the central portion

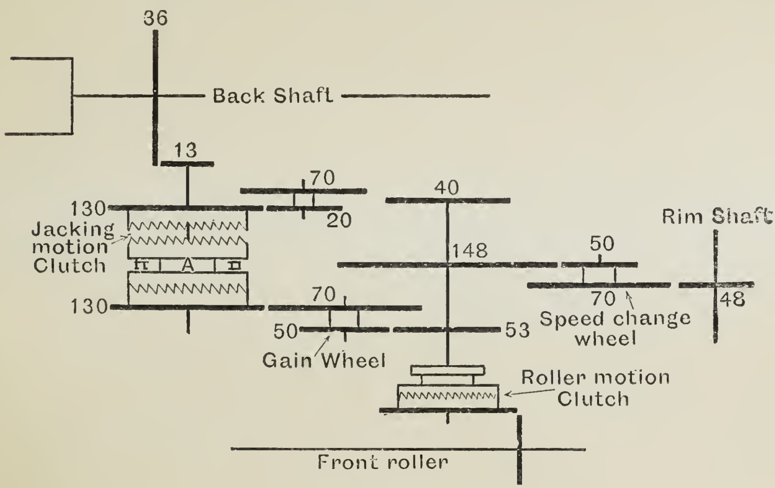

FIG. 38.

is connected to the shaft upon a feathered key or the equivalent. The clutch is now shown with the carriage driven at the normal rate. The movement of the clutch towards the back shaft to engage the other 130 part of this clutch, would set the back shaft moving at the slowest rate, namely—

$$\frac{\dfrac{53 \times 70}{50 \times 130} = \text{normal rate}}{\dfrac{40 \times 20}{70 \times 130} = \text{jacking rate}} = \tfrac{2}{13} \text{ the normal} = 6{\cdot}5$$

The Losses in Driving in Mules.—The following is an instance of the difference between the calculated and actual speeds of the parts in a mule when the former were made without allowances for losses arising from slippage in the non-positive gearing. The revolutions per minute of the line shaft was 235, and the connection to the rim shaft and spindles, respectively, $\frac{30}{15} \times \frac{28}{16}$, $\frac{17\frac{3}{8} \times 6}{11\frac{3}{8} \times \frac{3}{4}}$. The time taken to draw the carriage out to a head was $12\frac{3}{5}$ secs.

	The calculated revolutions in drawing the carriage out.	The actual revolutions in drawing out the carriage.		Loss per cent.
Rim shaft	172·5	138	=	18·8
Tin roller	263	211	=	24·0
Spindle	1537	2100	=	26·8
Percentage of slippage in driving from:				
The rim to spindles		8·9		
The rim to tin roller		5·2		
The tin roller to the spindles . . .		3·93		

The loss shown in the third column is inclusive, and represents the extent which the actual differs from the calculated.

Deductions.—The allowance in calculating the time taken, and the speed, during twisting, should be about 25 per cent. when the conditions are normal.

In arranging the driving gear, from 3 to 5 per cent. should be allowed for each band drive. The losses noticed in belt drives when the conditions are good—*i.e.* rational sizes of drums and widths of pulleys, and when not reversing—are only very slight, and need scarcely be taken into account.

In cases of very high speeds the losses will be greater. Considerable variation existed in the loss recorded at different spindles, most probably due to differences in their resistance and in the tension of their bands.

The slippage in the gear between the rim and line shaft is only slight when the best systems are adopted. The chief loss is that due to reversing.

Further examples of loss in driving mules follow.

Particulars relating to the Driving of the Parts in Fig. 35, Dobson and Barlow's Mule for Fine Numbers.

Revolutions of the line shaft, 235 per minute, actual, Drums on the line shaft, A, 32 inches ; B, 18 inches.

Counter Shafts.—The principal counter shaft: C, 20 inches ; D, 20 inches ; G, 12 inches ; E, 24 inches diameter.

The auxiliary counter shaft: H, 20 inches; I, 9 inches; K, 15 inches diameter.

Rim Shaft.—Fast and loose pulley, F, 16 inches ; hasten motion pulleys, J, 15 inches; rim pulley, 16 inches (12–22 inches), diameters.

Taking-in and Backing-off Motion Shaft Pulleys.—L, 14 inches diameter.

Spindles.—Rim, 16 inches; tin roller pulley, 10 inches ; tin rollers, 6 inches ; spindle wharves, $\frac{3}{4}$ inch diameters.

Rate of revolutions per minute of :—

The principal counter shaft—

$$\text{first speed, } \frac{235 \times 18}{20} = 211{\cdot}5$$

$$\text{second speed, } \frac{235 \times 32}{20} = 376$$

The auxiliary counter shaft—

$$\text{first speed, } \frac{235 \times 18 \times 12}{20 \times 20} = 126{\cdot}9$$

$$\text{second speed, } \frac{235 \times 32 \times 12}{20 \times 20} = 225{\cdot}6$$

The rim shaft—

$$\text{first speed, } \frac{235 \times 18 \times 24}{20 \times 16} = 317{\cdot}25$$

$$\text{second speed, } \frac{235 \times 32 \times 24}{20 \times 16} = 564$$

Under the hastening motion—

$$\text{High speed, } \frac{235 \times 32 \times 12 \times 9}{20 \times 20 \times 15} = 134$$

$$\text{Low speed, } \frac{235 \times 18 \times 12 \times 9}{20 \times 20 \times 15} = 76{\cdot}3$$

NOTE.—The latter are successively in action at the close of winding.

The rates of rotation per minute of spindles—

(1) $$\frac{235 \times 18 \times 24 \times 16 \times 6}{20 \times 16 \times 10 \times \frac{3}{4}} = 4060 \text{ first speed}$$

(2) $$\frac{235 \times 32 \times 24 \times 16 \times 6}{20 \times 16 \times 10 \times \frac{3}{4}} = 7219 \text{ second speed}$$

(3) $$\frac{235 \times 32 \times 12 \times 9 \times 16 \times 6}{20 \times 20 \times 15 \times 10 \times \frac{3}{4}} = 1732{\cdot}6$$ high speed during the action of the hastening motion

(4) $$\frac{235 \times 18 \times 12 \times 9 \times 16 \times 6}{1 \times 20 \times 20 \times 15 \times 10 \times \frac{3}{4}} = 974{\cdot}6$$ low speed ditto.

The Losses in Driving.—Under the above conditions in respect of the gear the actual rates of the spindles were observed to be less to the extent of: (1) 22·5 per cent.; (2) 23·5 per cent.; (3) 18·75 per cent.; (4) 11·15 per cent.

Further, the twist wheel contained 72 teeth, and moved 2 revolutions per draw; during twisting the movement was 140 teeth, and the revolutions of the spindle, in the corresponding period, 1454. This shows a loss of 18·8 per cent., the calculated speed being as follows:—

$$\frac{140 \times 16 \times 6}{10 \times \frac{3}{4}} = 1792$$

or 338 revolutions of the spindles more than the actual.

The time occupied in making this movement was $12\frac{1}{5}$ seconds at first speed, and $8\frac{1}{2}$ seconds at second speed, in these periods the actual revolutions of the spindles being, respectively, 672 and 782.

These speeds represent, respectively, the following average rates per minute:—

$$\frac{672 \times 60}{12\frac{1}{5}} = 3150, \text{ and } \frac{782 \times 60}{8{\cdot}5} = 5520$$

The loss of time by the rim shaft, as indicated by the above speeds, is therefore as follows—

Calculated revs. of rim shaft in			$8\frac{1}{2}$ secs. at	second speed			= 80·0
"	"	"	" $12\frac{4}{5}$	"	first	"	= 67·5
							147·5

Thus, 140 revolutions require the time of 147·5, or time lost by the rim shaft = 5·08 per cent.

From this it is seen that 5·08 per cent. of the 18·8 per cent. is between the rim and the driving shafts, the major portion, 13 per cent., being between the spindles and rim shaft.

Twist per Inch.—The length wound per draw was as follows:—

Distance moved by the carriage each draw	= 59·5″
Length del. by F.R. during the run-in of the carriage	= 4·5″
The approximate length wound	= 64·0″

$$\text{Actual twist per inch} = \frac{1454}{64} = 22{\cdot}7$$
$$\text{Calculated twist per inch} = \frac{1792}{64} = 28$$

The actual count spun was 60^s, so that the actual twist co-efficient $= \dfrac{22{\cdot}7}{\sqrt{60}} = 2{\cdot}93$, as against 3·62 calculated.

The front roller made the following movements each draw:—

(1) During the engagement of the F.R. clutch, $16\frac{1}{3}$ revolutions	= 54·6″
(2) During the jacking and twisting at the head actions, $\frac{1}{3}$ revolution	= 1″
(3) During the inward run of the carriage, 1 revolution	= 4·4″
Total length delivered per complete draw	= 60·0″
Length wound per draw	= 64″

The total stretching of the yarn per draw is, therefore, 64 − 60 = 4 inches. Of this, the amounts obtained during the above-named periods are—

(1) the movement of the carriage being $56'' = 56'' - 54{\cdot}6, = 1{\cdot}4$
(2) ,, ,, ,, $3\frac{1}{2}'' = 3\frac{1}{2}'' - 1, = 2{\cdot}5$

$$\frac{}{3{\cdot}9}$$

Length not accounted for $= 0{\cdot}1$

$$\frac{}{4{\cdot}0}$$

The actual revolutions of the rim shaft after the disengagement of the F.R. clutch, *i.e.* during jacking and twisting at the head, were 73. Therefore the length which should be delivered by the F.R. during this period, by reason of the action of the slow roller turning motion, is :

$$= \frac{73 \times 19 \times 20 \times 1 \times 24 \times 1\frac{1}{16} \times 22}{58 \times 40 \times 30 \times 24 \times 7} = 1{\cdot}332 \text{ inches}$$

The actual length observed was 1 inch. The difference was undoubtedly due to the backlash in the motion.

NOTE.—The difference noted in the actual and calculated rates of the spindle emphasize the importance of not relying on the calculated revolutions of the spindle unless due allowances have been made for slippage in the belt and band-driving gears. The use of a tachometer is very helpful when arranging the gearing. The particulars given were ascertained, accurately and expeditiously, by the aid of that instrument.

SPEED INDICATORS.

Losses in the Transmission of Motion, and how Ascertained.—The most convenient mode of ascertaining the extent of losses arising in the transmission of motion is by the aid of a self time-registering tachometer. The ordinary tachometer is defective in that the attachments for connections are imperfect, and in addition the timing has to be done either by a second person or the attentions of the operator divided between the timepiece and the tachometer. In either case the work is not altogether satisfactory.

The illustration (Fig. 39) is of a tachometer, and suitable attachments for spinning machinery. It consists of a recording

timepiece, D, with minutes and seconds dials combined on the

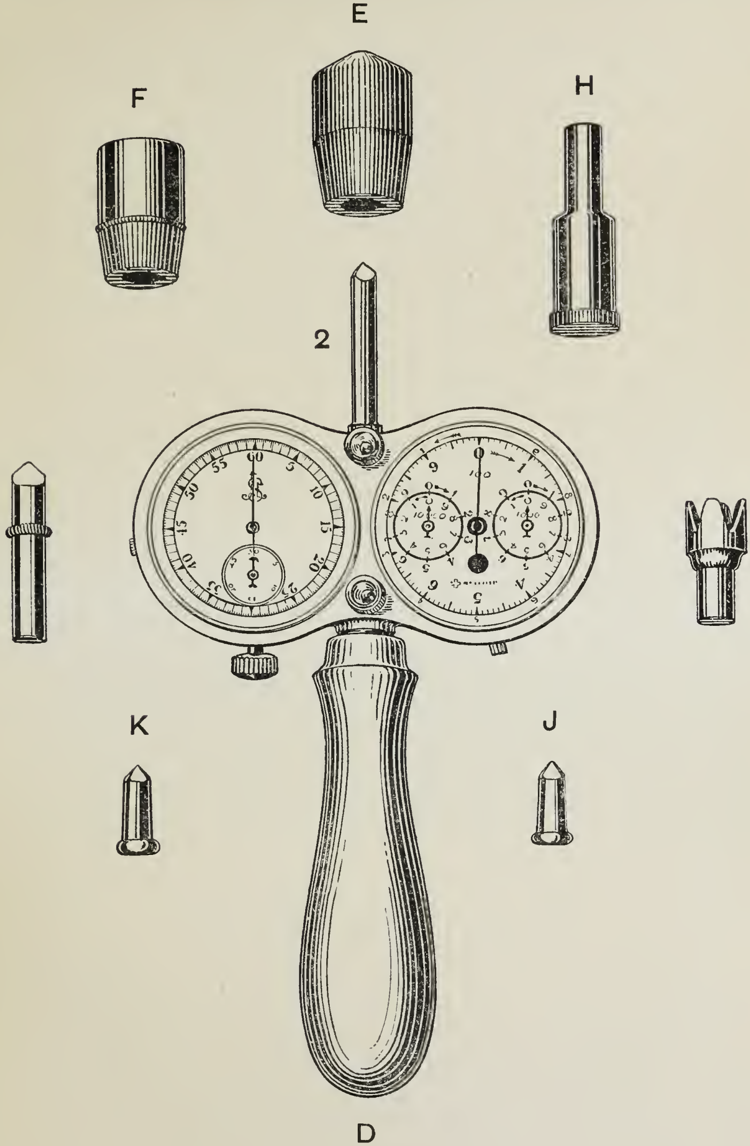

FIG. 39.

left hand. This is fitted with a fly-back action. The timing

commences upon pressure being applied to the recording spindle 2, the centre finger recording from $\frac{1}{5}$ to 60 seconds, and the lower finger the minutes. The lower projecting milled head is for setting back the minutes finger, and the slight projection on the left hand is the fly-back release for the seconds. The large right-hand deal finger indicates the revolutions up to 100, and the small one on the inner left the hundreds, whilst that on the inner right records the thousands. The projection on the underside of the right dial is the fly-back release for the unit-tens finger, the hundreds and thousands fingers being reset by means of milled heads at the back.

F, H, are rubber cupped detachable ends for the spindle of the tachometer.

E, and that on the left of centre are rubber pivoted detachable ends for the spindle of the tachometer.

That on the right of centre is a pyramidal recessed end for the spindle of the tachometer.

J, K are pyramidal ends for fitting to mule and ring spindles for use in connection with those found on the left and right of centre.

This instrument is held by the detachable handle D. In use its great feature is that it can be held in one hand, and with this exception the whole of the attentions of the operator are available for other work throughout the observations. The dials record the results, the range of speed being up to 10,000 revolutions per minute.

Length and Hank Indicators.

Fig. 40 shows the gearing in an indicator for registering the number of draws in mules. The segmental wheel is driven by a worm placed upon the back shaft of the mule (drawing-out shaft). The sector lever, b—b_1, secured to a, operates the star wheel c; to the latter a 3-treaded worm is secured, and this drives the worm wheel d on the spindle d_1—d_2. Five dial discs are mounted on this spindle, and these record units, tens, hundreds, thousands, and tens of thousands respectively. Each of these

are connected, in sequence, by a train 1 driving a 4, the latter being compounded with an 8, which drives the 20 secured to the next dial. The first dial is secured to d_1—d_2, and the rest are free upon it. Thus this instrument records from 0 to 99999

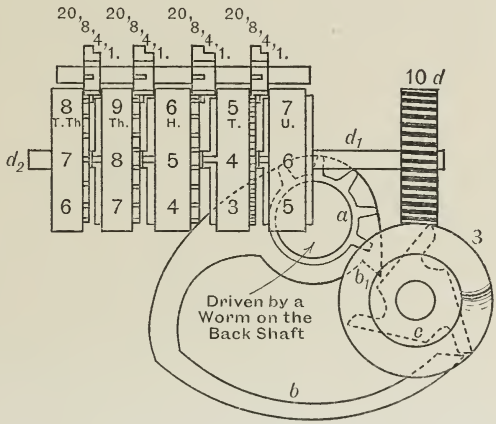

Fig. 40.

draws, the object being to record the work done in a given time for estimating the earnings and for other purposes.

The record is exact, as shown by calculation. Thus—

$$\frac{20 \times 4 \times 20 \times 4 \times 20 \times 4 \times 20 \times 4 \times 10 \times 3}{8 \times 1 \times 8 \times 1 \times 8 \times 1 \times 8 \times 1 \times 3 \times 1} = 100{,}000 \text{ hanks}$$

recorded on the dials by its moving from 00000 to 99999, and then 00000, or one complete revolution of the left-hand dial.

Fig. 41 shows the gearing in a hank indicator as used in mules. These instruments are arranged to record the production of the whole of the spindles in the machine, and hence the gear is varied to adapt them for the different numbers of spindles which the mules contain and the length of the draw. In the figure the particulars are of one designed for a mule containing

184 spindles only, and making a draw of $58\frac{1}{2}$ inches. It records from 0 up to 20,000 hanks, the customary allowance for loss through breakages being $2\frac{1}{2}$ per cent. The action in this case is as follows :—

a, a_1, a_2, a_3, a_4 are attached, this part is actuated by a worm, x, placed upon the back shaft. By that means a, a_1, a_2, oscillate, each draw, and the sector lever a_3a_4 moves the star wheel b one tooth. b is compounded with c, 30; this latter

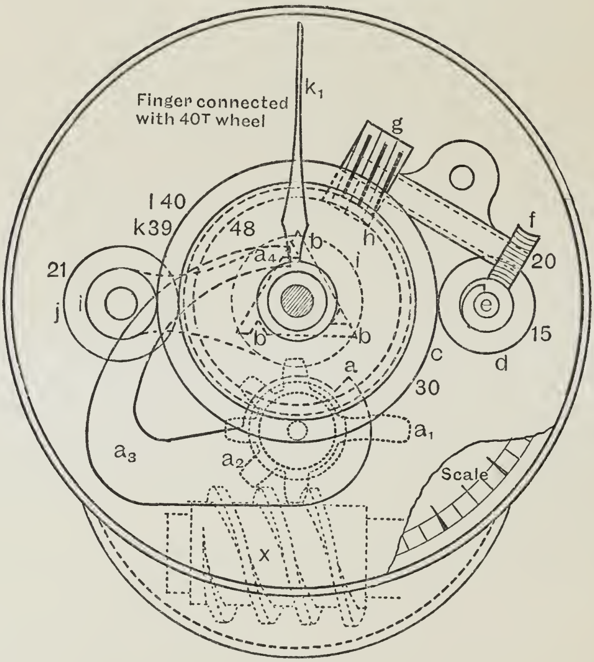

Fig. 41.

drives d, the 15. d is compounded with the worm e (1), which drives f (20). f is compounded with the single worm g, and the latter drives h. The lever i, i, is fastened upon the axle of h, and this is loose on the central spindle. At the extremity of this lever is the wheel 21, mounted free on a stud, and its teeth engage two wheels, k39 and l40 respectively, k being secured and cannot rotate. l, being free, is moved one tooth per revolution of the lever i, i, upon its centre. The index finger k_1 is

attached to l, and this moves in front of the dial indicating from 0 to 20,000 hanks.

The length of yarn made, per 184 spindles winding $58\frac{1}{2}$ inches per draw and assuming no loss, per 20,000 hanks registered,

$$= \frac{40 \times 48 \times 20 \times 15 \times 3 \times 184 \times 58\frac{1}{2}''}{1 \times 1 \times 1 \times 30 \times 1 \times 840 \times 36} = 20{,}503 \text{ hanks}$$

NOTE.—512 hanks = $2\frac{1}{2}$ per cent.

EXERCISE 1.—A mule containing 796 spindles and winding 67 inches per draw has the following wheels stamped upon it, $16 \times 6 \times 3 \times 41$, and it indicates 20,000 hanks per draw. What percentage does it allow for breakage?

Ans. 3·96, or 1·46 in excess.

EXERCISE 2.—For what number of spindles per mule would the following hank indicators be adopted? Particulars of their gear, $\frac{20}{1}, \frac{20}{1}, \frac{21}{1}, \frac{15}{30}, \frac{3}{1}$, assuming the length wound per draw 68 inches, and the indicator to record up to 20,000 hanks.

Ans. 686.

EXERCISE 3.—What number of hanks must be recorded per draw by the hank indicator in a mule containing 1200 spindles and winding 64 + 4 inches per draw, if $2\frac{1}{2}$ per cent. is allowed for breakage?

Ans. 2·63.

EXERCISE 4.—What alteration in the value of the following underlined portions of the gear in an indicator would adapt it for a mule of 1200 spindles, making a 64-inch draw and 4 inches inward roller delivery, allowing $2\frac{1}{2}$ for loss?

Value of the gear, $\underline{\frac{20}{1}, \frac{20}{1}, \frac{21}{1}}, \frac{15}{30}, \frac{3}{1}$.

Ans. Present value of the train = 12,600, or number of draws to move the dial one revolution.

Required value of the train = 7601, or number of draws to move the dial one revolution.

$$\text{Value of the gear required} = \frac{7601}{3 \times \frac{1}{2}} = 5067$$

Productions in Mules.

Count.	Production in hanks per spindle per 55½ hours inclusive.	Production in hanks per spindle per 55 hours inclusive.	Count	Production in hanks per spindle per 55½ hours inclusive.	Production in hanks per spindle per 55 hours inclusive.
	Twist.	Weft.		Twist.	Weft.
16s–28	32–35	30-34	61s–80	16·75–19·75	17–20·5
30	31–33	31–33	82	16·5–19·5	—
32	29–32	30–32	84	15·75–19·25	—
34	28–31	29–31 2	86	15·5–19	16·5–20
36	27·5–30·8	28·5–31	88	15·25–18·8	—
38	27–30	28–30·75	90	15·1–18·6	16–19·7
40	26·5–29·5	27–29·5	92	14·9–18·4	—
42	26–29	26·5–29	94	14·8–18 1	—
44	25·5–28·5	26–28·5	96	14·6–17·75	15·5–19·3
46	25–28	25–28	98	14·4–17·5	—
48	24·5–27·5	24·5–27·5	100	14·2–17·25	15–19
50	24–27	24–27	110	14–17	15–18·5
52	23·5–26·5	23·5–26 5	120	13·7–16·5	14–17·25
54	23–26	23–26	130	13·3–15·5	13·5–16
56	22·5–25·5	22·5–25·5	140	13–14·25	—
58	22–25	22–25	150	12·26–14	—
60	21·5–24·5	22·5–26·5	160	12–13	—
62	21–23·5	22–26	170	11–12	—
64	20–22·5	21·5–25·6	180	10–11	—
66	19·5–22	21–24–8	190	9·5–10·5	—
68	19–21·5	20–24	200	9–10	—
70	18·5–21·25	19·5–23·2	240	7·2–8·2	—
72	18–21	19–22 8	260	6·4–7·4	—
74	17·5–20·5	—	280	5·6–6·6	—
76	17·25–20·25	18–21·9	300	4·9–5·9	—
78	17–20	—			

The Ring Frame.—Figs. 42 and 43 represent the gearing common in ring frames.

A = The back roller and its wheel for driving that on the middle roller.

B = The carrier wheel connecting the back and the middle rollers.

C = The wheel upon the middle roller.

D = The draft change wheel on the back roller.

E = The draft change pinion driving the back roller wheel.

F = The crown wheel compounded with the draft change pinion and gearing with the front roller wheel.

G = The wheel on the front roller for driving the above gear.

H = The wheel on the front roller gearing with the train I, J, and K.

K = The twist change wheel.

L = The twist stud wheel, and MN the connecting train from the tin roller shaft.

N = The tin roller shaft wheel, this is changed when an extension in the range of the twist is desired beyond that procurable by altering the twist wheel.

P, P_1 = The tin rollers driving the spindle bands.

Q = The spindle wharve. The spindles are arranged in rows on either side. The band indicated by the dotted lines shows the driving when double tin rollers are used for one side only.

Fig. 43 shows the driving of the cam W for reciprocating

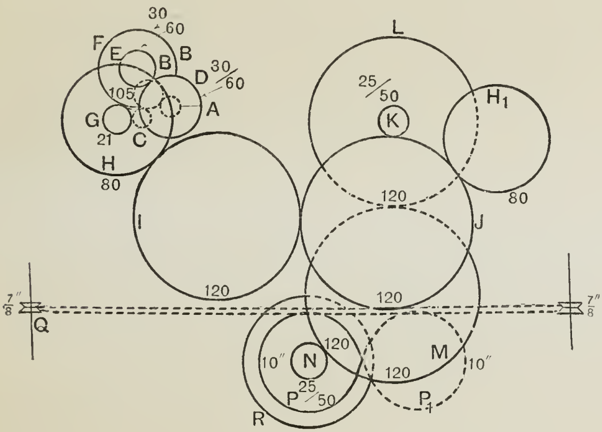

Fig. 42.

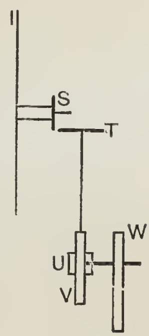

Fig. 43.

the ring rail, the rate at which this is driven controls the pitch of the coils contained by the bobbin.

S, T, U, V, are the train of wheels connecting W with I. W produces the reciprocation of the ring rail through the medium of a series of levers, rods and chain connections. The relative positions of their movement is advanced through the agency of a ratchet wheel and a pawl, the ratchet wheel being termed the builder wheel.

The number of teeth in the builder wheel and the value of its driving train, S, T, U, V, control the length, and therefore

the weight of yarn placed upon the bobbins. When the rate of reciprocation is insufficient, and other means have been exhausted, the speed of this part is changed by introducing a single, double, or a treble worm at T. The movement of the pawl operating the ratchet is adjustable to the extent of the varying sizes of the teeth in the builder wheels applicable.

D, E, F, G, are the gear for driving the rollers on the right-hand side, and these are a duplicate of those on the left side.

R, is the driving pulley connected by belt or rope with the line shaft.

The speeds of the spindles in these machines usually range from 6000 to 11,000 per minute, actual. The usual sizes of rollers are from $\frac{7}{8}$ to $1\frac{1}{8}$ inch for the front and back positions, and $\frac{1}{8}$ less for the middle roller; $\frac{7}{8}$ inch is used for short and $1\frac{1}{8}$ inch for long-stapled cottons.

The recognized twist for ring yarns is $4\sqrt{\text{count}}$ per inch. This is not rigidly adhered to, exceptions being made when it secures better spinning and the amount of the twist has not been stipulated.

The Speeds of Spindles.—The circumstances that govern the best speeds of the spindles are: quality and count of the roving and yarn; condition of the machine; expertness of the workers. Under the most favourable conditions, a speed of 10,500 revolutions actual may be attained with counts 30^s–36^s. For other counts, under the best conditions, the following revolutions per minute of spindle are given as a guide:—

For counts below 30^s—

$$\frac{10000\sqrt{\text{intended count}}}{\sqrt{30}}$$

For counts above 36^s—

$$\frac{10000\sqrt{36}}{\sqrt{\text{intended count}}}$$

When the conditions are identical but not satisfactory for the above:

For counts below 36^s—

$$\frac{\text{known satisfactory speed} \times \sqrt{\text{intended count}}}{\sqrt{\text{count}}}$$

For counts above 36^s—

$$\frac{\text{known satisfactory speed} \times \sqrt{\text{count}}}{\sqrt{\text{intended count}}}$$

With the largest and smallest sizes of the twist change wheels given in Fig. 42, and the spindles making 10,000 revolutions per minute, the speed of the parts would be as follows:—

Parts.	With the smallest change wheels.	With the largest change wheels.
Tin roller shaft and machine pulley	$\frac{10000 \times \frac{7}{8}}{10} = 875$	875
Front rollers	$\frac{10000 \times \frac{7}{8} \times 25 \times 25}{10 \times 120 \times 80} = 57$	228

With rollers of the following diameters, the lengths delivered per minute respectively are—

Parts.	With the smallest change wheels.	With the largest change wheels.
By front roller, $\frac{7}{8}''$ diameter .	$\frac{57 \times \frac{7}{8} \times 22}{7} = 157''$	$\frac{228 \times \frac{7}{8} \times 22}{7} = 628''$
By front roller, $1\frac{1}{8}''$ diameter .	$203''$	$812''$

The twist per inch under the above conditions would therefore be—

Parts.	With the smallest change wheels.	With the largest change wheels.
By front roller, $\frac{7}{8}''$ diameter . . .	$\frac{10000}{157} = 63{\cdot}7$	$\frac{10000}{628} = 15{\cdot}9$
By front roller, $1\frac{1}{8}''$ diameter . . .	$\frac{10000}{203} = 49{\cdot}2$	$\frac{10000}{812} = 12{\cdot}3$

Thus the twist, with the sizes of change wheel applicable and the front roller $\frac{7}{8}$ inch in diameter, ranges from 15·9 to 63·7 turns per inch of yarn delivered by the front roller.

This calculation is based on the twist being equal to the revolutions of the bobbin. This is inaccurate when the yarn is unwound from the side of the bobbin, but correct when the yarn is unwound from the ends of the bobbins. To arrive at the actual twist inserted during spinning, it is necessary to deduct from the revolutions of the bobbin, the revolutions about the bobbin made by the yarn in obtaining winding.

The different sizes of the twist wheels applicable would therefore obtain the following amounts of twist when the tin

roller wheel is 25 and the front roller is $\frac{7}{8}$ inch in diameter :—

Size of twist wheel	25	26	27	28	29	30 . . .	35 . . .	40 . . .	45
Twist per inch . .	63·7	61·2	59·0	56·8	54·9	53·0 . . .	45·5 . . .	39·8 . . .	35·3

Size of twist wheel	46	47	48	49	50
Twist per inch . .	34·6	33·9	33·2	32·5	31·8

The above are ascertained in the following manner :—

Revolutions of spindle per inch delivered by the front roller

$$= \frac{80}{\text{T.W.}} \times \frac{120}{\text{T.R.W.}} \times \frac{10''}{\frac{7''}{8}} \times \frac{1}{\frac{7''}{8} \times \frac{22}{7}}$$

and hence with a 25 tin roller wheel, and a 50 twist wheel, the revolutions of the spindle per inch delivered by the front roller

$$= \frac{80}{25} \times \frac{120}{59} \times \frac{10}{\frac{7}{8}} \times \frac{1}{\frac{7}{8} \times \frac{22}{7}} = 31·8$$

These results may also be ascertained as follows :—Assuming that the tin roller wheel was 25, and the twist wheel contained only one tooth, the twist per inch would be 63·7 × 25. (This is called the twist change wheel constant number for a 25 tin roller wheel, and the front roller $\frac{7}{8}$ inch in diameter.)

$$\therefore \frac{63·7 \times 25}{26} = \text{the twist per inch when a 26 wheel is used}$$

$$\text{or, } \frac{\text{T.W. constant}}{\text{intended wheel}} = \text{the twist per inch}$$

$$\therefore \frac{\text{T.W. constant}}{\text{twist per inch}} = \text{required wheel}$$

When the limit in the range of sizes of twist wheels is reached, they may be rendered again available by altering the size of the tin roller wheel, in the proportion which the range of wheels represent. The limit in the present instance is reached, with a 25 tin roller wheel, when the twist wheel is 50, the twist in the yarn is 31·8 per inch. By adopting the size of tin roller wheel that, together with a 25 twist wheel, will produce 31·8 twists per inch, the range of twist wheels are again available. Thus—

$63{\cdot}7 \times 25 =$ the tin roller change wheel constant number for a twist change wheel of 25 teeth

$$\therefore \frac{63{\cdot}7 \times 25}{31{\cdot}8} = \text{the required tin roller wheel} = 50$$

and, therefore, with a 50 tin roller wheel, and with the stated range of twist wheels, the following twists will be obtained :—

Size of twist wheel	25	26	27 . . .	30 . . .	34	35 . . .	40 . . .	45
Twist per inch . .	31·8	30·6	29·4 . . .	26·5 . . .	23·4	22·9 . . .	19·8 . . .	17·6

Size of twist wheel	46	47	48	49	50
Twist per inch . .	17·3	16·9	16·5	16·2	15·9

Twist change wheels are usually drivers in the train to the front rollers, and therefore increasing their size increases the length of yarn submitted for twist in direct proportion, and hence the twist is reduced inversely.

To change the Counts.—This is done in the same way as in the previous machines—

(*a*) By altering that of the feed.

(*b*) By altering the extent of the attenuation or draft.

The results are directly proportional to alterations in either case. Thus :

$$\frac{\text{the weight unit of the feed}}{\text{draft}} = \text{the weight unit of the delivery, and } vice\ vers\hat{a}$$

the count of the feed × the draft = that of the delivery, and *vice versâ*

The draft is also determined in the same manner. Assuming, the smallest driver, and the largest driven, of the draft change wheels are used, and the back and front rollers alike in size, then—

$$\text{the draft} = \tfrac{60}{30} \times \tfrac{105}{21} = 10$$

Hence, with the back roller wheel 60, the range of pinions, applicable, would produce the following drafts :—

Draft pinion	30	31	32	33	34	35 . . .	40 . . .	50 . . . 55
Draft . . .	10·0	9·65	9·37	9·1	8·82	8·57 . . .	7·5 . . .	6·0 . . . 5·45

Draft pinion	56	57	58	59	60
Draft . . .	5·35	5·26	5·17	5·08	5·0

It is thus seen that the fractional change in the draft corresponds with the fractional change in the wheel, and hence large wheels command a finer adjustment of the count, and for this reason the use of small change wheels should be avoided as far as practicable.

Whenever the size of pinion required is not available, alter the back roller wheel in the inverse proportion, or change the back roller wheel, altering its size to the extent that will enable the use of the available wheels, as pinions. The following is then the procedure:—

Ratio of pinion and back roller wheels, $\frac{\text{back R.W.}}{\text{pinion}}$; and any two wheels which give a near enough ratio will be satisfactory.

Always remember that the back roller wheel has the inverse effect to the pinion, the former affecting the draft in the direct ratio and the latter inversely.

The Builder Wheel (Ratchet).—In changing the count, the weight of the yarn is affected in the inverse proportion, so that if the bobbins are required to contain the same weight, then the ratchet wheel must be changed in direct proportion to the count. This is not always admissible in practice on account of the bobbins being filled too full for the rings, through the yarn not being wound sufficiently compact. The rule in calculating the builder wheel is—

$$\frac{\text{Builder wheel} \times \text{count required}}{\text{count spun}} = \text{wheel suitable}$$

When the size of the empty bobbins are changed or a different size of full bobbin is required, the wheel should be altered in direct proportion to the area of the cross-section of the yarn contained on the full bobbin.

The relative area of a cross-section of the yarn = (diameter of full bobbin − diameter of empty bobbin)^2.

$$\therefore \frac{\text{the wheel} \times \text{area of section of yarn on bobbin required}}{\text{area of section of yarn on present bobbin}}$$

When the bobbins are insufficiently hard, and the traveller is the heaviest practicable, speeding up the traverse of the ring rail by the most convenient of the wheels S, T, U, V, will have a beneficial effect.

Exercises in changing the Counts and other Conditions of Spinning in the Ring Frame (Fig. 42). The Front and Back Rollers are taken at $\frac{7}{8}$ Inch in Diameter.

Particulars.	Exercise numbers.							
	1	2	3	4	5	6	7	8
(1) Count of the yarn	37·5	40	50	60	80	30	20	16
(2) Count of the rove	?	10	?	15	20	?	$3\frac{1}{2}$	?
(3) Rove, whether single or double	2	2	2	2	2	1	1	1
(4) Draft	?	?	10	?	?	6	?	5·3
(5) Draft wheels—								
F.R.W. . .	21	21	21	21	21	21	21	21
C.W. . . .	105	105	105	105	105	105	105	105
P.W. . . .	40	?	?	?	?	ratio	40	ratio
B.R.W. . .	60	60	60	60	57	?	?	?
(6) Twist per inch .	?	25·3	?	31	?	?	17·9	?
(7) Twist wheels—								
T.R.W. . .	50	50	25	25	25	50	50	50
T.W. . . .	?	?	?	?	?	?	?	?
(8) Twist change wheels constant number	795	795	?	?	?	?	?	?
(9) Revolutions of spindles per minute	10,000	9500	9000	8500	8000	10,500	9000	8000
(10) Size of empty and full bobbins	$\frac{3}{4}''$ and $1\frac{3}{8}''$	—	—	—	$\frac{3}{4}''$ and $\frac{1}{4}''$	$\frac{3}{4}''$ and $1\frac{1}{2}''$	$\frac{3}{4}''$ and $1\frac{1}{2}''$	$\frac{3}{4}''$ and $1\frac{5}{8}''$
(11) Builder wheel .	36	?	?	?	?	?	?	?
(12) Hanks produced per 10 hours (no allowances)	?	?	?	?	?	?	?	?

Answers to Exercises.

Particulars.	Number of Exercise.							
	1	2	3	4	5	6	7	8
No. 1	—	—	—	—	—	—	—	—
„ 2	10	—	10	—	—	5	—	3
„ 4	7·5	8	—	8	8	—	5·72	—
„ 5	—	35	30	35	35	P. 5 B.R.W. 6	46	P. 50 B.R.W. 53
„ 6	24·5	—	28·3	—	35·8	21·9	—	16
„ 7	32·4	31·4	56·2	51	44·5	36	44	50
„ 8	—	—	1590	1590	1590	795	795	795
„ 11	—	38	48	58	49	41·5	27·6	30
„ 12	8·1	7·46	6·33	5·45	4·45	9 5	10·3	16·6

Examples in the Working of the Exercises on Page 211.

Exercise 1.—The draft = $\frac{60}{40} \times \frac{105}{21}$; the count of the rove = $\frac{37\cdot5 \times 2}{\text{draft}}$; the twist per inch = $4\sqrt{\text{count}}$; twist wheel = $\frac{795}{4\sqrt{\text{count}}}$; the hanks produced = $\frac{\text{revolutions of F.R. per 10 hours} \times \text{circle of F.R.}}{\text{inches per hank}}$.

Exercise 2.—The draft = $\frac{40}{\frac{10}{2}} = 8$; the pinion wheel ($x$) is contained in this equation $\frac{60}{x} \times \frac{105}{21} = 8$; the twist wheel = $\frac{795}{25\cdot3}$, or, as x in the following equation, $\frac{80}{x} \times \frac{120}{50} \times \frac{10}{\frac{7}{8}} \times \frac{1}{\frac{7}{8} \times \frac{22}{7}} = 25\cdot3$; the builder wheel = $\frac{36 \times 40}{37\cdot5} = 38\cdot4$.

Losses in driving the Spindles in Ring Frames.—The following are instances of the observed and calculated speeds of the spindles, together with the losses arising from slippage :—

Ring frame with two tin rollers, one of these being fixed to the machine shaft, and the other driven by the spindle bands.

	Driver T.R. side.	Driven T.R. side.
Actual revolutions of T.R.	565	555
Actual revolutions of spindle	6250	5824
Calculated revolutions of spindle . . .	6460	6342
Percentage of loss	3·25	8·1

The following were recorded after rebanding the spindles on the driven tin roller side, these bands being driven by the driver tin roller :—

	Driver T.R. side.	Driven T.R. side.
Actual revolutions of T.R.	570	562
Actual revolutions of spindle	6026	6020
Calculated revolutions of spindle . . .	6541	6422
Percentage of loss	6·67	7·5

The following were recorded in a frame having the tin rollers connected by an endless rope drive :—

	Driver side.	Driven side.
Actual revolutions of T.R.	658	650
Actual revolutions of spindle	7184	7065
Calculated revolutions of spindle . . .	7500	7430
Percentage of loss	4·2	4·7

The productions in ring frames vary considerably, depending

upon the speed of spindles, twist per inch,[1] strength of the yarn, skill of the operatives and their management.

The spindles are run at rates as high as 11,000 revolutions per minute, this being exceptionally high, and only practicable under the most favourable conditions. The production ranges as high as 96 per cent. of the calculated when based upon the actual spindle speed.

The highest speeds are only practicable with about 36^s to 40^s counts under normal conditions.

PRODUCTIONS IN RING SPINNING.

Count.	Actual speeds of spindles per minute.	Production in hanks per spindle per 55½ hours.	Count.	Actual speeds of spindles per minute.	Production in hanks per spindle per 55½ hours.
16	7000–8000	43–51	40	9500–11,000	39–45
20	7500–8500	43–48	50	8500–10,000	31–37
24	8000–9000	42–47	60	8500–10,000	28–34
28	8500–9500	41–46	70	8000–9000	25·5–30
36	9000–10,500	39–45	80	8000–8500	24–25·5

Productions in Ring Spinning.—In spinning yarns from single roving, with a high draft, or from an inferior or irregular stapled or soft cotton, or in exposed buildings, lower speeds are necessary.

The ring spinning machine cannot be as profitably employed in the production of yarns other than the best descriptions, when in competition with those produced in the mule spinning machine.

Ring frames require better cotton and finer roving for the ordinary classes of yarn. They are principally employed, in this country, in the production of the following yarns :—

(1) Yarns containing above the average twist.

(2) Yarns made from above the average quality of cotton for the count.

(3) Yarns of above the average quality.

(4) Yarns which are required in bundle or warp form for the subsequent requirements.

In all these, this machine can produce to greater advantage when the counts are within a certain range.

[1] See effects of twists in single yarns, p. 215.

Twist Standards for Single Yarns.

The object in applying twist in spinning yarn is to secure a common bond amongst the fibres, and thereby create a certain tensile resistance to tension. The purposes for which the yarn is required will therefore control the extent of the twist applied.

The ordinary standards in use are as follows :—

Mule Yarns.—

Turns per inch in—

$\sqrt{\text{count}} \times 3{\cdot}18$ = Egyptian weft
$\sqrt{\text{count}} \times 3{\cdot}25$ = American weft
$\sqrt{\text{count}} \times 3{\cdot}39$ = Egyptian medium
$\sqrt{\text{count}} \times 3{\cdot}5$ = American medium
$\sqrt{\text{count}} \times 3{\cdot}606$ = Egyptian twist
$\sqrt{\text{count}} \times 3{\cdot}75$ = American twist

Ring Yarns.—

"Soft weft" = $\sqrt{\text{count}} \times 3{\cdot}25$
"Medium weft" = $\sqrt{\text{count}} \times 3{\cdot}5$
"Soft twist" = $\sqrt{\text{count}} \times 3{\cdot}75$
$\sqrt{\text{count}} \times 4{\cdot}0$ = Ordinary twist
$\sqrt{\text{count}} \times 4{\cdot}25$ = Water twist
$\sqrt{\text{count}} \times 4{\cdot}5$ = Hard twist
$\sqrt{\text{count}} \times 4{\cdot}75$ = Extra hard twist
$\sqrt{\text{count}} \times 5{\cdot}5\text{–}9{\cdot}0$ = Crêpe

The above twists are not rigidly adhered to. Slight modifications are made in them by the spinner, such as circumstances connected with the operation of spinning render expedient.

A knowledge of the effects of twist, apart from the ordinary standards, is most essential in spinning.

The influence wielded by twist varies with the character of the cotton. It is greater in those fibres which are long, uniform in their length, and silky in texture, and well prepared. The shade of the yarn is always darkened with increased application, and the touch is also hardened. A decided curl, or shrink, is also thereby developed. This latter tendency is greatest in yarn which is irregular in diameter or made from harsh cotton.

Yarns that are highly twisted are less absorbent and colder to the touch, more difficult to dye satisfactorily. Such often become weaker in sizing, bleaching, and dyeing, whereas those less twisted are not unusually strengthened thereby.

The Effects of Twist in Single Yarn.—The effect of twist upon the strength of yarn is graphically illustrated in Fig. 44. This diagram was prepared from the breaking resistance of 20^s yarn made from Gd. Brown Egyptian cotton. This, in its preparation, had been combed and otherwise most

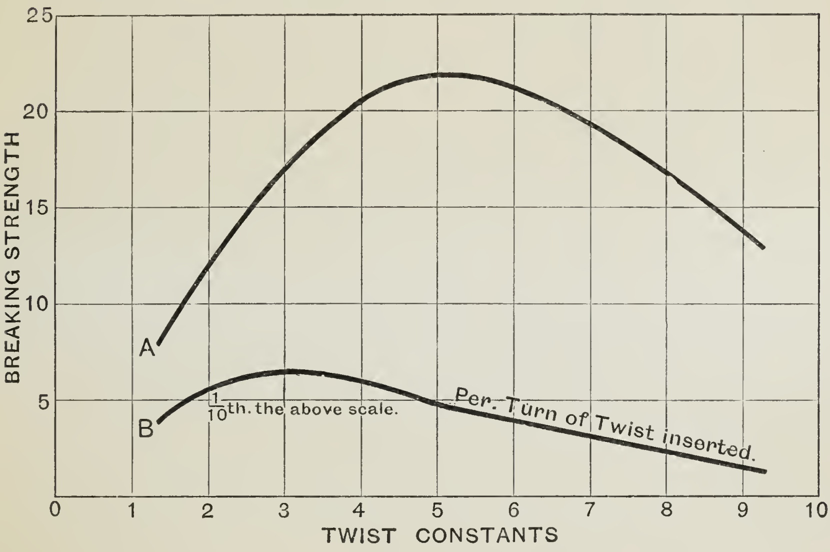

Fig. 44.

carefully prepared. In spinning, double roving was used. These abnormal conditions being considered essential for the end in view, as it must be recognized that to obtain the most satisfactory results, such work could only be useful by attaining the best conditions. Yarns were prepared containing twist ranging from 13 to 41·5 turns per inch. In testing their strength the greatest care was exercised to ensure reliable results. Altogether the number of tests made exceeded 12,000.

In testing the yarns, considerable difficulty was experienced,

in using the ordinary strength testers, with those hardest twisted, and the results obtained were unreliable.

Ultimately, the tests were accomplished, satisfactorily, by using the Moscrop patent single thread tester made by Messrs. Cook of Manchester. The whole of the tests, made use of in plotting this diagram, were executed on the same machine.

The diagram gives the strength developed in terms of an increasing twist constant, and also in strength per turn of twist. The upper curve shows the former, and indicates the point at which twist ceases to add to the strength, and the lower curve shows that obtaining the greatest value in strength per turn of twist inserted.

The inferences drawn from these tests, and from inspection of the yarn, are—

(*a*) That in the best yarns the strength contributed per turn of twist becomes gradually less at $\sqrt{\text{count}} \times 3$.

(*b*) That in the best yarns the strength ceases to increase with the added twist at $\sqrt{\text{count}} \times 5$.

(*c*) That the shade and touch and tendency to shrink becomes appreciably affected after $\sqrt{\text{count}} \times 3{\cdot}5$.

(*d*) That the shade is only very slightly affected up to $3{\cdot}0\sqrt{\text{count}}$, and after $5\sqrt{\text{count}}$ it becomes very appreciably darkened.

(*e*) A coincidence was that the twist constant realizing the greatest strength per turn of twist was $3{\cdot}17\sqrt{\text{count}}$. That adopted by the trade generally in spinning weft from Egyptian cotton is $3{\cdot}18\sqrt{\text{count}}$.

Twist Standards for Folded Yarn.—The following are the twist constants used in doubling:—

Twofolds—

XXXX Soft	1·34
XXX ,,	1·52
XX ,,	1·8
X ,,	2·2
,,	2·8
Medium	3·39
Common	4·0

Lisle	4·5
Double spun	5·0 (singles)
Hard	5·0
X ,, ...	5·4
XX ,, ...	5·6

Sewings Constant or Co-efficient.

Single yarn.	Twofold.	Six-cord.
As low as possible	$\sqrt{\frac{\text{single count}}{2}} \times \text{constant}$ 4·5	$\sqrt{\frac{\text{single constant}}{6}} \times \text{constant}$ 6·5

Crochet.

Single yarn.	Twofold.	Six-cord.
Weft to twist turns . .	6·5	5·5

Yarns for Fish Netting.

Single yarn.	Twofold.	Six-cord.
Common	$\sqrt{\frac{\text{single count}}{\text{number of singles}}} \times 4{\cdot}5$	$\sqrt{\frac{\text{single count}}{\text{number of singles}}} \times 6{\cdot}5$

Knitting Yarns and Embroidery and for Mercerizing.

Singles.	Fold.
As low as practicable . .	$\sqrt{\frac{\text{singles}}{\text{number of singles}}} \times 3{\cdot}0 \text{ to } 3{\cdot}25$

The Influence of Direction of Twist in Folded Yarn.

The diagram (Fig. 45) shows the influence of the direction of twist upon the strength in the twofold yarn. This figure was plotted from the breaking strains of two series of twofold yarns, one set being twisted reversely and the other twisted in the same direction as that contained in the singles. The

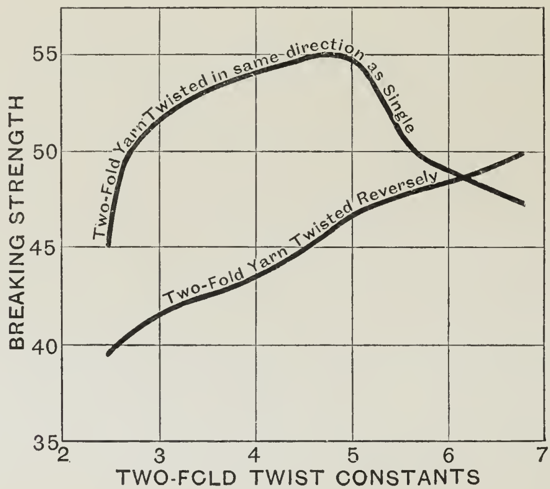

Fig. 45.

single yarns used were of very good quality and all alike, containing twist to the extent of $3{\cdot}6\sqrt{\text{count}}$, per inch. The twofold twists, per inch, ranged from $2{\cdot}5\sqrt{\text{count}}$ to $6{\cdot}85\sqrt{\text{count}}$. Those twisted in the same direction as the single were harder to the touch and darker in shade, and with the increased twist, their elasticity, to tensile resistance, increased to an abnormal extent. Yarns for elastic fabrics and in preparing for sewing threads have their twist in this direction. Those twisted in the reverse direction exhibited no abnormal features; a slightly darkening shade was noticeable especially in those fullest twisted.

The Influence of Varying Degrees of Single and Folding Twist.—Fig. 46 was prepared from the breaking strains of yarns containing a graduated extent of twofold twist, and made from

single yarn containing the following twists per inch: (1) 2·9, (2) 3·35, (3) 3·9, and (4) 4·5 times the $\sqrt{\text{counts}}$. The doubling twist was inserted in the reverse direction to that in the singles, and the twofolds comprised 20 differently twisted threads, ranging in extent from $\sqrt{\text{counts}} \times 2{\cdot}75$ to $\sqrt{\text{counts}} \times 5{\cdot}95$.

The following were the most noticeable differences in features of these yarns:—

Number (4) gave the best strength when containing doubling twist to the extent of $5\sqrt{\text{count}}$ and below. It was small and pearly.

Number (1) was the most attractive yarn, being softest, most

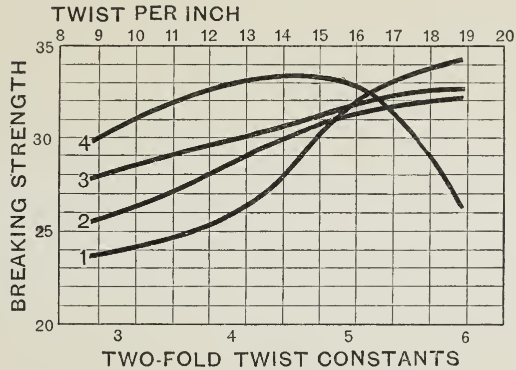

FIG. 46.

cylindrical, and lustrous. In point of strength, however, it is inferior to the others, up to $4{\cdot}9\sqrt{\text{counts}}$, turns per inch, but a little beyond this point its strength is superior to the others. Of the four types this would be the most expensive yarn to produce.

This figure is useful in indicating the twofold twist most beneficial in variously twisted single yarns; also the most serviceable single twist when a given twist is desired in the twofold.

The Effects of Twisting Two or More Single Threads together.— When the twist inserted is in the reverse direction to that contained in the singles, it displaces an equal amount from each of them. When the twisting proceeds in the same direction as

that contained in the singles, that in the singles is supplemented to the extent of the doubling twist. Thus, the former procedure removes the twist in the singles, the fibres being simply re-arranged convolutely, or in what may be termed a spiro-corrugate order. When tension is applied to bodies of fibres so arranged they are pressed towards a common centre, and this force bonds them, preventing the fibres from sliding.

It is this change in the arrangement of the fibres, without necessarily changing their compactness, that is responsible for the greatly increased strength of doubled yarn as compared with that of single yarn of a similar weight.

The conditions that would have to obtain in order to utilize to the fullest extent the available strength of the body of fibres contained in a doubled yarn, are—

That all fibres be equally outstretched and in alignment, so that they mutually share the tension applied. That they are bonded sufficiently to prevent their slippage upon each other and devoid of individual twist.

This latter state, in so far as twist is concerned, can readily be obtained. It is in the laying of the fibres equally outstretched that difficulty arises, that state being only partially possible. The formation of the fibres about a common centre, twisted, renders their alignment impossible.

The aims of doubling may be stated as follows :—

(1) To permanently utilize the available strength of the fibres by preventing their axial movement after the thread is completed.

(2) To obtain the desired compactness, lustre, and freedom from ooze, with the fibres bonded in the most suitable manner for the required size of thread.

(3) To insure definite elastic properties in the yarn when under tension.

(4) To obtain the desired character of surface, such as cylindrical, spiral, corkscrew, pearly, crêpe, or other effects.

In order to secure the utmost strength, and at the same time prevent axial movement, the twists in the successive stages should be arranged so that they balance in the completed yarn.

Compactness is the result of tension and compression applied during doubling. In order to obtain the smallest thread from a number of others, as, for example, in sewings and kindred yarns, the following procedure is most effective:—

In doubling the singles the fibres should be compressed to their limit, by twisting in the same direction as the singles, and to the extent necessary to obtain a balanced state when the final twisting is completed. Thus, when the final twist is great, that in the folded singles must also correspond. In the substitution of the preparing by the final twist the consequent extending and expanding tendencies are fully absorbed, or counteracted by their greater radius about a common centre.

Lustre is affected by the angle which the fibres make with the completed thread. It is greatest when they are in line with the axis of the individual singles, and *vice versâ*. Thus, lustre indicates the extent of the twist in the singles and in the fibres.

Freedom from Ooze.—This is in the main the result of the rolling action of the yarns against each other in the course of twisting.

The Tendency to Stretch, under tension, is regulated by the angle of the singles or strands comprised in the final thread. The more numerous these are the less their stretching tendency. Thus, highly elastic doubled yarns are composed of the fewest singles and strands. The number of strands that can be satisfactorily bound in this way are limited, and hence they seldom exceed four. Above this number the singles or strands have insufficient adherence, and hence plaiting is resorted to.

Cylindricity is developed most effectively when the singles are only slightly twisted and of the best quality.

Pearly Effects are developed by employing highly twisted singles.

Crêpe by twisting in the same direction as the singles, also by inserting considerable twist in the reverse direction to that in the singles; but the effect is not the same in both cases.

Spiral Effects are obtained by slight folding twist.

Where a small yarn with hard effects are required, highly twisted singles are necessary. For soft effects similar to those

required in yarns for mercerizing, the singles should be softly twisted.

Corkscrew Effects are obtained by doubling—

(*a*) Yarns in unequal tension.

(*b*) Yarns unequal in size.

(*c*) Yarns containing unequal twist.

(*d*) Yarns twisted in opposite direction.

The Relative Resistance of Yarns to Twist.—Assuming the co-efficient of resistance to the first twist in a given length of yarn to be 1, and the resistance, as the twist progresses, directly proportional to the twist contained, the relative resistance, when the diameters of the yarns are not alike, being proportionate to their diameters cubed—then, upon these assumptions, the relative resistance of a body of untwisted fibres, equal to 60^s and 40^s yarns, are respectively—

$$\left(\frac{1}{\sqrt{60}}\right)^3 \text{ and } \left(\frac{1}{\sqrt{40}}\right)^3$$

When the fibres are twisted, their resistance, when t denotes the twist contained in them, will be respectively—

$$t\left(\frac{1}{\sqrt{60}}\right)^3 \text{ and } t\left(\frac{1}{\sqrt{40}}\right)^3$$

The above are based on other conditions being equal.

The relative resistance of 60^s and 40^s yarns containing twist to the extent of $3{\cdot}5\sqrt{\text{count}}$, is therefore expressed as follows:—

$$60^s,\ 3{\cdot}5\sqrt{60}\left(\frac{1}{\sqrt{60}}\right)^3 = {\cdot}057$$

$$40^s,\ 3{\cdot}5\sqrt{40}\left(\frac{1}{\sqrt{40}}\right)^3 = {\cdot}0837$$

When folded threads are required balanced, namely, without tendency to twist or untwist, it is necessary to insert twist to the extent that will balance the forces they contain. Thus, a yarn composed of several single threads should be twisted so that the force developed by the doubling twist is sufficient to counteract those still contained in the singles. When a number of singles

are bound by twist in this manner, the twist inserted adds to, or reduces, that in each single, to a corresponding extent. This action reduces or increases the force which the singles exert. Therefore, when the doubling twist is inserted in the reverse direction to that in the singles, and to the extent of rendering the opposing forces equal, the yarn is then in a state of equilibrium or "still." The amount of twist, which is required to produce the still or balanced state, will be governed by that contained in the singles and also by the number of threads comprised in folding. Hence, the more numerous the twists in the single and the fewer the folds, the greater the amount of twist required in doubling the yarn.

The extent of the twist required in folding yarns to balance that in the single yarn may therefore be ascertained in the following manner :—

Let c_1 = the count of the single.
c_2 = ,, ,, folded yarn.
T_1 = the twist in the single yarn.
T_2 = ,, required in the folded yarn.

The relative twist required to develop a balance of the forces in the completed thread, when twofold, is as follows :—

The force in the singles before folding is :

$$2\left[t_1\left(\frac{1}{\sqrt{c_1}}\right)^3\right]$$

The force due to the twist remaining in the singles when doubling is completed is :

$$2\left[(t_1 - t_2)\left(\frac{1}{\sqrt{c_1}}\right)^3\right]$$

The force due to the doubling twist in the thread is :

$$\left(\frac{1}{\sqrt{c_2}}\right)^3 t_2$$

Therefore, the forces in a balanced thread are :

$$2\left[(t_1 - t_2)\left(\frac{1}{\sqrt{c_1}}\right)^3\right] = \left(\frac{1}{\sqrt{c_2}}\right)^3 t_2$$

The above formula, when applied to twofold 50[s] with $t_1 = 3{\cdot}5\sqrt{c_1}$, gives the following results:—

$$\left[(3{\cdot}5\sqrt{c_1} - t_2)\left(\frac{1}{\sqrt{50}}\right)^3\right]2 = \left(\frac{1}{\sqrt{\frac{50}{2}}}\right)^3 t_2$$

$$t_2 = 10{\cdot}9$$

This method of ascertaining the twist is applicable to all kinds of yarns. It enables that necessary, in the singles, to balance a certain folding twist to be ascertained, or *vice versâ*. Adherence to this method would necessitate considerably more twist, in the single yarn, than it is customary to apply, and hence it would increase the cost and this without commensurate return. In certain classes of yarns it is applied to some extent.

The application of the above formula is further illustrated by the following example:—

Let the count of the single be 50, and twofold is made containing the usual turns $\sqrt{c_2} \times 4 = 20$. What twist would be necessary in the singles in order that the completed twofold be in perfect balance?

$$2\left[(t_1 - t_2)\left(\frac{1}{\sqrt{c}}\right)^3\right] = \left(\frac{1}{\sqrt{c_2}}\right)^3 t_2$$

$$\therefore \left[(x\sqrt{50} - 20)\left(\frac{1}{\sqrt{50}}\right)^3\right]2 = \frac{1}{\sqrt{25}}20$$

$$x\sqrt{50} = 46{\cdot}5$$

$x = 6{\cdot}58$, the single twist coefficient or constant

The Ring Doubling Frame.

Fig. 47 represents the gearing common in ring doubling frames, A, A_1 being the rollers, and L the driving pulleys, J the tin roller, and I the tin roller shaft wheel, the train I, H, G, E, E_1, D, D_1, C_1, B, and B_1, being the trains of wheels connecting the front rollers to the tin roller. K and K are the spindles.

The following twist is obtained when the smallest sizes of the change wheels are employed:—

The revolutions of the spindle per one of the roller, with the smallest sizes of change wheels, are—

$$\frac{75 \times 60 \times 120 \times 8}{20 \times 20 \times 20 \times 1\frac{1}{8}} = 480$$

and therefore the twist per inch inserted in the yarn, on the left side of this machine, would be—

$$\frac{480}{1\frac{3}{4} \times \frac{22}{7}} = 87{\cdot}27$$

whilst that on the right side would be—

$$\frac{480}{2\frac{1}{2} \times \frac{22}{7}} = 61$$

The range of twist with 20–60 the available sizes of top

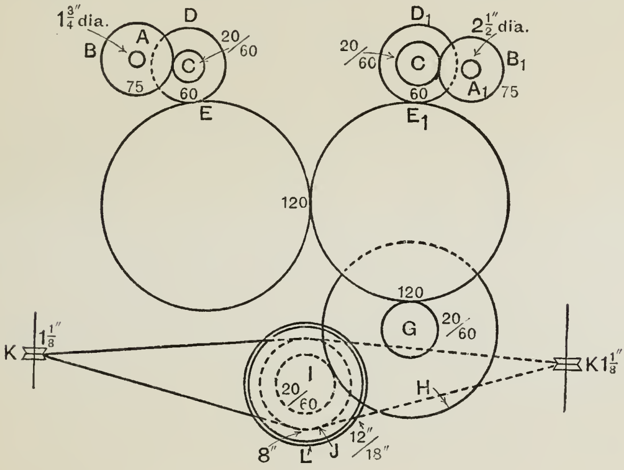

Fig. 47.

change wheels, when the tin roller and the lower twist wheels are both 20, is—

On the left side, from 87·27, to $87{\cdot}27 \times \frac{20}{60} = 29{\cdot}09$

On the right side, from 61, to $61 \times \frac{20}{60} = 20{\cdot}3$

With the available sizes of wheels for G, when the tin roller wheel is 20 and C is 60, the twist per inch procurable, ranges from

On the left side, from 29·09, to $\frac{29{\cdot}09 \times 20}{60} = 9{\cdot}69$

On the right side, from 20·3, to $\frac{20{\cdot}3 \times 20}{60} = 6{\cdot}77$

With the tin roller 40 and the other change wheels 60 and 60, the twist would be—

$$\text{On the left side, } \frac{9{\cdot}69 \times 20}{40} = 4{\cdot}89 \text{ twist per inch}$$

$$\text{On the right side, } \frac{6{\cdot}77 \times 20}{40} = 3{\cdot}38 \text{ twist per inch}$$

$$\text{The production per unit of time} = \frac{\text{revolutions of spindle (actual)}}{\text{twist required}}$$
$$= \text{inches per unit of time}$$

Therefore with the spindles making 8000 revolutions per minute (actual), and the counts 2–72^s and twist coefficient 4·5, the rate of production in hanks and ounces per spindle per 10 hours, no allowances, would be—

$$8000 \times 60 \times 10 = \text{revolutions of spindle per 10 hrs.}$$

$$\frac{8000 \times 60 \times 10}{4{\cdot}5\sqrt{\frac{72}{2}}} = \text{inches per spindle in 10 hrs.}$$

$$\frac{8000 \times 60 \times 10}{4{\cdot}5\sqrt{\frac{72}{2}} \times 36} = \text{yards per spindle in 10 hrs.}$$

$$\frac{8000 \times 60 \times 10}{4{\cdot}5\sqrt{\frac{72}{2}} \times 36 \times 840} = \text{hanks per spindle in 10 hrs.}$$

$$\frac{8000 \times 60 \times 10 \times 16}{4{\cdot}5\sqrt{\frac{72}{2}} \times 36 \times 840 \times \frac{72}{2}} = \text{ounces per spindle in 10 hrs.}$$

This is assuming the yarn does not contract.

$$\frac{8000}{4{\cdot}5\sqrt{\frac{72}{2}} \times 1\frac{3}{4} \times \frac{22}{7}} = \text{revolutions of the roller per minute on the left side}$$

$$\frac{8000}{4{\cdot}5\sqrt{\frac{72}{2}} \times 2\frac{1}{2} \times \frac{22}{7}} = \text{revolutions of the roller per minute on the right side}$$

With the particulars of the frame as given in the figure, the different top change wheels that would be applicable, in order that the same turns may be put in the yarn made on both sides of the machine, are as follows: The ratio of these change wheels, left to right, should be as $2\frac{1}{2} : 1\frac{3}{4}$, or $10 : 7$, or $1 : 0{\cdot}7$.

The following exercises are based on the conditions obtaining in Fig. 47:—

EXERCISES 1. What size of wheel B_1 would give twist identical to that on the left side with top change wheels 20?

2. Assuming B_1 and B 107 and 75, respectively, with the top change wheels C, C_1 alike and G, 60, whilst the yarn doubled is 2–60s; what sizes of G would be suitable for using 2–70s, 2–80s, 2–90s, the same twist coefficient in each instance?

3. Assuming the tin roller wheel 20 and bottom change wheel G 20, what size of C and C_1 would be necessary for 2–120s on both sides, the twist constant being 4·5?

4. Assuming that 2–120s, containing 35 turns per inch, is being doubled on both sides, at what rates per minute should the rollers rotate?

5. What twist per inch would be inserted when the $2\frac{1}{2}$-inch roller is observed to make 1 revolution per 70 of the spindle?

6. If the twist is 8·0 turns per inch with a 60 lower change wheel, what size of wheel will give 24 turns? Also, at what rate must the roller rotate per minute in both instances, assuming the spindle makes 600 revolutions per minute?

7. The top and bottom change wheels are 60 and 40 respectively, and the present twist is 24·8 turns, but 25·8 are required: which change wheel would alter to get the nearest to this, and what size of wheel would be necessary?

8. If the twist per inch was 24·8 and the top and bottom change wheels, 60 and 40 respectively, are each changed for wheels three teeth less, what would be the alteration in the twist?

9. Give several sets of top and bottom change wheels which would give identical twists to those obtained with: 20 top and 60 bottom, 21 top and 56 bottom.

Changes in the sizes of the tin roller shaft and bottom change wheels, affect both sides equally.

Alterations in the twist by means of the top change wheels must be made, on both sides, inversely to the changes in the twist required.

The rate of the production is altered, by changes in any of those wheels, in the direct proportion to the alteration. When changing counts of yarns, and the twist, required, involves the same twist coefficient, then the sizes of the wheels required are inversely as the $\sqrt{\text{counts}}$. Thus, if changing from 2–30s to 2–40s, present wheel : required wheel : : $\sqrt{\text{intended count}}$: $\sqrt{\text{present count}}$.

When the wheels required for carrying out the change desired at one or two of these points are not available, the results desired may be obtained by changing at the other points in the same proportion.

The speed of the spindles applicable for various counts

range from 3000 to 8500, according to the class of work. When changing, always consider whether the new circumstances will admit of or require a change in the speed of the spindles. Such is made by altering the frame shaft pulleys or their drivers, whichever be most convenient.

Slippage in Doubling Frames.—In doubling frames there is usually considerable slippage in driving the spindles from the tin roller, and this often results in undesirable variations in the twist which the yarn contains. An idea of the extent of this is contained in the following observed speeds in a ring doubling frame in good working condition. This frame contained one tin roller making 838 revolutions per minute and 8 inches in diameter, the spindle wharves being $1\frac{1}{8}$ inch in diameter. The following were typical records of their speeds per minute: 5186, 5100, 5416, 5265, their calculated rate being 5950, and hence the loss was 12·8, 14·3, 9·0, 11·5 per cent. respectively. This is when neglecting the size of the spindle band. It will be noticed that when the size of the spindle band is allowed for in this instance, the loss will be almost *nil*.

The Twiner Mule.—Fig. 48 contains particulars of the gear for driving the spindles and drawing-out scroll shaft in a twiner.

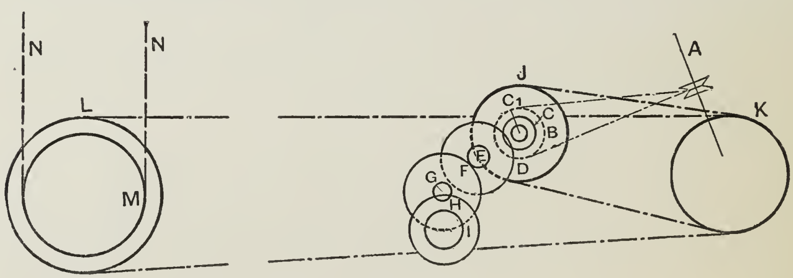

Fig. 48.

N, N are the strap driving the rim pulley M; L is the rim pulley, and LK the rim band driving the tin roller pulley J, K being the rim band carrier pulley. The tin roller B drives the spindle wharve A; C and C_1 are the tin roller wheels, shown in two sizes, for driving the train D, E, F, G, H; H is the drawing-out shaft clutch wheel. The other particulars of the above gear are

as follows:—Revolutions per minute of run shaft, 770. Rim, L, 12–24 inches; B, 6 inches; J, 11 inches; A, $\frac{7}{8}$ inch diameters respectively. C and C_1, 15 and 25; D, 80; E, 20–40; F, 90; G, 15; H, 68, teeth respectively. H makes $3\frac{54}{68}$ revolutions per draw in moving the creel out 72 inches. The twist change wheels are: the tin roller 15 and 25, and the wheel E 20 to 40.

The rim pulley is seen, on inspection of this gear, to be the medium for adjusting the speed of all the productive parts, and the twist change wheels for altering the rate at which the yarn is introduced to the twisting influence.

If the examples relating to the spinning mule have been understood, the following calculations will be understood.

Hence only one example is given in each set of these calculations.

Exercise 1.—Calculate the revolutions of the spindles per minute with consecutive sizes of rims ranging from 12 to 24 inches in diameter.

Example.—Revolutions per minute of speed when the rim is 12 inches in diameter,

$$= \frac{770 \times 12 \times 6}{11 \times \frac{7}{8}} = 5760$$

Size of rim	12″	13″	14″	15″	16″	17″	18″	19″	20″	21″	22″	23″	24″
Revs. of spindle per minute	5760	6240	6720	7200	7680	8160	8640	9120	9600	10,080	10,560	11,040	11,520

Exercise 2.—Calculate the twist per inch when the largest driver twist change wheels are in use.

Example.—Revolutions of spindle per one draw and per $3\frac{54}{68}$ revolutions of H—

$$\frac{3\frac{54}{68} \times 68 \times 90 \times 80 \times 6}{15 \times 40 \times 25 \times \frac{7}{8}} = \text{twist per draw of 72 inches}$$

$$\therefore \text{ the twist per inch} = \frac{258 \times 68 \times 90 \times 80 \times 6 \times 8}{68 \times 15 \times 40 \times 25 \times 72 \times 7} = 11{\cdot}8$$

When the tin roller wheel is 25 and the twist change is	40	39	38	37	36	35	34	33	32
The twist per inch is	11·8	12·1	12·4	12·7	13·05	13·4	13·8	14·3	14·7

31	30	29	28	27	26	25	24	23	22	21	20
15·2	15·7	16·2	16·8	17·4	18·1	18·8	19·6	20·5	21·4	22·4	23·5

Exercise 3.—Calculate the twist change wheel that will give the nearest to 23·5 turns per inch when the tin roller wheel is 15.

Exercise 4.—Calculate the twist per inch with consecutive sizes of twist change wheels ranging from 20 upwards, with the tin roller wheel 15.

Ans. Twist change wheel . .	20	21	22	23	. . .	30
Twist per inch . . .	39·4	37·5	35·8	34·2		26 3

$$Example.\ \frac{258 \times 68 \times 90 \times 80 \times 6 \times 1}{68 \times 15 \times 20 \times 15 \times 72 \times \frac{7}{8}} = 39{\cdot}4$$

Exercise 5.—If the twist change wheel 35 and the counts doubled $\frac{50^s}{2}$, what sizes of wheels would be required for $\frac{60^s}{2}$, $\frac{70^s}{2}$, $\frac{80^s}{2}$, $\frac{90^s}{2}$, $\frac{100^s}{2}$, when the same twist constant is used?

$$Example.\ \frac{35\sqrt{\frac{50}{2}}}{\sqrt{\frac{60}{2}}} = \text{wheel suitable for } \frac{60^s}{2}$$

Exercise 6.—Estimate the production in hanks per spindle and in pounds per twiner of 1000 spindles per 10 hours; the spindles to develop a speed of 11,000 revolutions per minute, and backing off and winding to occupy 5 seconds; the counts doubled are $\frac{50^s}{2}$, $\frac{60^s}{2}$, $\frac{70^s}{2}$, $\frac{80^s}{2}$, $\frac{90^s}{2}$, $\frac{100^s}{2}$, and the twist constant 4·5 is used. Allow 15 per cent. for loss of speed during twisting, and 15 minutes per doff, the cops weighing 2 ozs. each.

Example.—$\frac{50^s}{2}$.

$$\text{Seconds taken twisting per draw} = \left(\frac{4{\cdot}5\sqrt{\frac{50^s}{2}} \times 72}{11000}\right)60\ \frac{100}{85} = 10{\cdot}04 \text{ seconds}$$

$$\text{Seconds per complete draw} = 10{\cdot}04 + 5 = 15{\cdot}04$$

$$\text{Time to make a cop in seconds} = \frac{\frac{2}{16} \times 25 \times 840 \times 36}{72 \times 85} = 15{\cdot}04 \text{ seconds}$$

$$\text{The above numerators} = \text{contents of a cop in inches}$$

$$\left.\begin{array}{r}\text{Time taken to make a cop and}\\ \text{doff in hours}\end{array}\right\} = \frac{1 \times 25 \times 840 \times 36 \times 15{\cdot}04}{8 \times 72 \times 60 \times 60} + \frac{15}{60}$$

$$= 5 \text{ hrs. } 29 \text{ mins.} + \frac{15}{60} \text{ hrs.} = 5{\cdot}733 \text{ hrs.}$$

$$\therefore \text{ production in hanks per spindle} = \frac{10 \times 2 \times 25}{5{\cdot}733 \times 16 \times 1} = 5{\cdot}45$$

$$\therefore \text{ production in pounds per twiner} = \frac{1000 \times 5{\cdot}45}{\frac{50}{2}} = 218 \text{ lbs.}$$

Changing the size of the rim affects the speed of all the parts concerned in twisting and introducing the yarn, and therefore alters the time occupied, in making this movement, in direct proportion; the time taken to back off and wind remaining unaffected.

Changing the twist change wheel alters the twist through affecting the rate of movement of the carriage, in the direct proportion to the change made in the wheel. This alters the

rate of the carriage movement inversely to the twist, the productive rate being affected in the proportion which this alteration affects the period of twisting.

Example.—Assuming a draw is made in 15·04 seconds, when the twist change wheel is 35, and of this 5·0 seconds is the time occupied in backing off and winding; the following alteration would arise in the event of employing a 23 twist change wheel:—

$$\frac{10{\cdot}04 \times 35}{20} = \text{time in seconds occupied in twisting}$$

$$\therefore \text{time per draw} = 17{\cdot}57 + 5 = 22{\cdot}57$$

The rate of production is therefore altered in the terms of 15·04 : 22·57 = 0·666, and not in proportion to the change in the wheels, 0·657.

Costs of Yarn.

The following are given as representing about the average costs of the various items of expenditure in South-East Lancashire mills in the production of mule yarns of medium count from uncombed cotton when spun from single roving:—

	Cost in pence per spindle per annum.
Banding—Twine—Rope	0·5
Carriage on cotton and other materials	2·3
Coal	3·75
Paper	0·15
Cleaning cloths—Engine packing—Brushes	0·25
Leather and cloth for rollers	0·5
Belting and its accessories	0·25
Lubricants	0·9
Repairs: Mill buildings—Machinery and upkeep: basis 1½ per cent. at 24*s.* per spindle per annum	4·32
Gas and water	1·0
Rates and taxes	2·0
Stationery — Telephone — Exchange — Railway tickets—Stamps—Printing and sundry office expenses	1·0
Sundry stores	0·5
Insurance	0·45
Interest at 5 per cent. at 25*s.* per spindle	15·0
Depreciation at 4 per cent. on 24*s.* per spindle	11·52
Wages	36·0
	80·64

Percentage of wages to other expenses . . . 45

In order to ascertain the cost of producing yarn when the production and the inclusive expenses per spindle are known, the following is the course usually followed:—

To the cost of the cotton at the card delivery add the cost of production, per pound, and deduct the sum received, per pound of yarn spun, for the waste.

The rate of the production per spindle in the South-East Lancashire district does not vary considerably. The range is given on p. 204.

In costing it is usual to disregard the loss arising from waste after the card, because this item is about balanced by the regain in conditioning. The value of the waste is assessed at $2\frac{1}{2}$ per cent. of the cotton price; this is considered a fair value.

EXAMPLE of the cost of 28ˢ T. made from Middling American cotton at 6*d.* per pound.

		Cost in pence per pound.
Working costs per spindle per annum	80·64	
Production per spindle per annum, based on 50 working weeks per year and 32 hanks per week	$\frac{32 \times 50}{28}$	= 1·413
Cost of the cotton delivered at the card delivery, allowing 10 per cent. for loss, $\frac{6 \times 100}{90}$		6·67
		8·083
Less value of the waste	0·15	
„ cost of raw cotton	6·0	
		6·15
Nett cost of spinning		1·933

Add: cost of selling and discounts $3\frac{1}{2}$ per cent on selling price.

EXAMPLE 36ˢ T. from F. Middling American cotton at 6·16*d.* Production, 30 hanks per spindle per week.

		Cost in pence per pound.
Working costs per spindle per annum, 80·64 Production per spindle per annum, 50 × 30 hanks	$= \frac{80 \cdot 64 \times 36}{30 \times 50}$	= 1·935
Cost of the cotton at the card delivery, allowing 10 per cent. loss		6·844
		8·779
Less value of the waste	0·154	
„ cost of the cotton	6·16	
		6·314
Nett cost of spinning		2·465

EXAMPLE 60^s T. Fair Br. Egyptian at 9*d.* per pound.

		Cost in pence per pound.
Working costs per spindle per annum . . . . . / Production per spindle per annum	$\dfrac{80{\cdot}64}{\frac{24}{60} \times 50}$	= 4·032
Cost of the cotton delivered at the card 10 per cent. wasted, $\dfrac{9 \times 100}{90}$		10·0
		14·032
Less value of the waste	0·225	
,, cost of cotton	9·0	9·225
Nett cost of spinning		4 807

THE APPROXIMATE COSTS OF YARN WHEN SPUN FROM SINGLE ROVING, THE BASIS BEING 80·64 PENCE COST PER SPINDLE PER ANNUM = 1·61 PENCE PER SPINDLE PER WEEK.

Count and description of yarn.	Production in hanks per spindle per 55½ hours.	Suitable cotton and grade.	Price of cotton at the time of compilation.	Probable percentage of waste up to carding inclusive.	Cost of cotton at carding head per pound, due to loss.	Estimated value of waste made up to carding.	Working expenses per pound of yarn spun.	Prime cost of yarn in pence per pound.	Margin between prime cost of yarn and that of the raw cotton.
16 W.	34	½ G.O. American, ½ {G. Broach, G. Tinnevelly}	5·55	12	6·31	0·137	0·76	6·933	1·383
16 T.	34	G.O. American	5·71	12	6·48	0·142	0·76	7·098	1·388
16 T. super.	33	s.L.M. ,,	5·95	11	6·68	0·149	0·783	7·314	1·364
20 T.	34	b. ,,	5·86	11	6·58	0·147	0·95	7·383	1·523
20 W.	34	G.O. ,,	5·71	12	6·48	0·142	0·95	7·288	1·578
24 T.	34	s.L.M. ,,	5·95	11	6·68	0·149	1·14	7·671	1·721
24 W.	34	f.G.O. ,,	5·81	12	6·6	0·145	1·14	7·595	1·785
30 T.	32	b.M. ,,	6·05	11	6·8	0·151	1·15	7·799	1·749
30 W.	32	s.L.M. ,,	5·95	11	6·68	0·149	1·15	7·681	1·731
32 T.	30	M. ,,	6·09	10	6·77	0·152	1·72	8·338	2·329
36 T.	29	f.M. ,,	6·2	10	6·9	0·155	2·0	8·745	2·545
36 W.	31	b. ,,	6·05	11	6·8	0·151	1·88	8·529	2·524
40 T.	28·5	G. ,,	6·31	10	7·0	0·158	2·26	9·102	2·792
42 W.	28·5	s. ,,	6·15	10	6·83	0·154	2·38	9·056	2·906
50 T.	26	M.F. ,,	6·55	10	7·28	0·164	3·1	10·216	3·666
50 W.	26	G.M. ,,	6·31	10	7·0	0·158	3·1	9·943	3·633
60 T.	23	Special select grades only							
60 W.	24	M.F. American	6·55	10	7·28	0·164	4·03	11·146	4·596

In those spinning mills preparing the yarn from double roving, at the spinning machine, the cost of the working expenses are

greater than those previously given. This has been ascertained to approximate 1·72*d*. per mule spindle per week.

Thus, 50ˢ T. from double rove, and produced at the rate of 25·5 hanks per mule spindle per week, will cost in working expenses—

$$\frac{1{\cdot}72 \times 50}{25{\cdot}5} = 3{\cdot}37d. \text{ per pound}$$

and 60ˢ T. at 23·5 hanks per spindle per week—

$$\frac{1{\cdot}72 \times 60}{23{\cdot}5} = 4{\cdot}4d. \text{ per pound}$$

The Appoximate Cost of Yarn spun from Double Roving as per Data previously given.

Count and description of yarn.	Production in hanks per 55½ hours.	Suitable grade of cotton.	Price of cotton at date of compilation.	Probable percentage of waste up to carding head.	Cost of the cotton passing the carding head per pound.	Estimated value of the waste made up to and included in carding.	The working expenses per pound of yarn spun.	Prime cost of yarn spun in pence per pound.	Margin or difference between the price of the cotton and prime cost of yarn.
16 W.	34	½ G.O. American, ½ {Broach G. / Tinnevelly G.}	5·55	12	6·31	0·137	0·80	6·978	1·428
16 T.	34	G.O. American	5·71	12	6·48	0·142	0·805	7·143	1·433
16 T. super.	33	s.L.M. „	5·95	11	6·68	0·149	0·83	7·361	1·411
20 T.	34	b.L.M. „	5·86	11	6·58	0·147	1·01	7·443	1·583
20 W.	34	G.O. „	5·71	12	6·48	0·142	1·01	7·348	1·638
24 T.	34	s.L.M. „	5·95	11	6·68	0·149	1·22	7·75	1·8
24 W.	34	f.G.O. „	5·81	12	6·6	0·145	1·22	7·675	1·865
30 T.	32	b.M. „	6·05	11	6·8	0·151	1·61	8·209	2·209
30 W.	32	s.L.M. „	5·95	11	6·68	0·149	1·61	8·141	2·191
32 T.	30	M. „	6·09	10	6·77	0·152	1·84	8·458	2·368
36 T.	29	f.M. „	6·2	10	6·9	0·155	2 35	9·05	2·875
36 W.	31	b.M. „	6·05	11	6·8	0·151	2·0	8·65	2·6
40 T.	28·5	G.M. „	6·31	10	7·0	0·158	2·41	9·252	2·942
42 W.	28·5	s.M. „	6·15	10	6·83	0·154	2·53	9·206	3·056
50 T.	26	M.F. „	6·55	10	7·28	0·164	3·31	10·426	3·876
50 W.	26	G.M. „	6·31	10	7·0	0·158	3·31	10·152	3·842
60 T.	23	{Peeler, Baders, Boweds, or super Orleans or Texas}	—	10	—	—	—	—	—
60 T. super American.		{Ditto (double rove)}	—	—	—	—	—	—	—
60 W.	24	M.F. American	6·55	10	7·28	0·164	4·03	11·416	4·866
50 T.	25·5	Egy. G.F.	9	11	10·1	3·37	0·225	13·24	4·24
50 W.	26·5	U. Egy. F.	$8\frac{3}{16}$	11	9·2	3·25	0·204	12·25	4·07
60 T.	23·5	Egy. G.	$10\frac{1}{8}$	10	11·25	4·4	0·253	15·40	5·27
60 W.	25	U. Egy. G.F.	$9\frac{3}{16}$	11	10·3	4·13	0·229	14·20	5·02
70 T.	20·5	{½ Egy. G. / ½ „ F.G.F.}	$10\frac{3}{8}$	10	11·53	5·88	0·259	17·15	6·77

Count and description of yarn.	Production in hanks per 55½ hours.	Suitable grade of cotton.	Price of cotton at date of compilation.	Probable percentage of waste up to carding head.	Cost of the cotton passing the carding head per pound.	Estimated value of the waste made up to and included in carding.	The working expenses per pound of yarn spun.	Prime cost of yarn spun in pence per pound.	Margin or difference between the price of the cotton and prime cost of yarn.
70 W.	22·5	U. Egy. F.G.F.	9⅞	10	11·0	5·35	0·247	16·10	6·22
80 T.	18·5	Egy. G.	11¼	10	12·5	7·44	0·281	19·66	8·41
80 W.	19·5	U. Egy. G.	10⅛	10	11·36	7·05	0·253	18·16	6·29
90 T.	17·0	Egy. F.	11⅞	9	13·05	9·1	0·297	21·85	9·97
90 W.	19·0	U. Egy. F.	10¼	10	11·4	8·15	0·256	19·30	9·05
100 T.	15·0	Egy. F.	10⅞	10	13·05	11·4	0·297	24·22	13·34
Combed Qualities—					Cost of cotton at the comber head.	*	*		
80 T.	19	Egy. F.	11⅞	10+18	16·4	7·25 +0·9026	0 295 +1·07	23·1876	11·3151
90 T.	17·5	”	11⅞	10+18	16·4	8·85 +0·9026	0·295 +1·07	24·7876	12·9151
100 T.	16·0	”	11⅞	10+18	16·4	10·75 +0·9026	0·295 +1·07	26·6876	14·8151

The plus items in columns marked * refer to the extra cost through the combing process. The particulars of these are given on p. 239.
The productions per spindle are given on p. 204.

Costs of producing Yarns by Ring Spinning.—The cost of preparing the cotton up to the roving for ring spinning is greater than for mules. In the roving stage the cost is from 25 to 33 per cent. more on account of finer roving required. This necessitates more machinery for preparing the roving. The costs of labour in the spinning process, when producing the classes of yarn for which ring frames are most adapted, is in some cases as much as 50 per cent. less than in mule spinning process. Besides the extra preparation, a better class of cotton has to be used, and even then the yarn is not in a convenient form for transport when it leaves the spinning machine. The cost for winding the yarn in a convenient form for sale is considerable. This latter item is dealt with in another part of this work.

The following are the yarn and cotton quotations for June 29, 1906. These are given for comparison with the estimated costs contained on the foregoing pages.

From the "Manchester Guardian," June 30, 1906.

	Good Bhownuggar. Per pound.	20^s water twist. Per pound.	Middling American. Per pound.	32^s cop twist. Per pound.	Fully good fair Egypt. Per pound.	60^s twist Egypt. Per pound.
1905.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
September 1	5	$8\frac{5}{8}$	5·83	$8\frac{3}{4}$	$7\frac{15}{16}$	$13\frac{5}{8}$
,, 8	$4\frac{15}{16}$	$8\frac{3}{8}$	5·56	$8\frac{5}{8}$	$7\frac{15}{16}$	$13\frac{5}{8}$
,, 15	$4\frac{13}{16}$	$8\frac{3}{8}$	5·50	$8\frac{3}{8}$	$7\frac{15}{16}$	$13\frac{3}{8}$
,, 22	$4\frac{13}{16}$	$8\frac{3}{8}$	5·64	$8\frac{3}{8}$	$7\frac{15}{16}$	$13\frac{3}{8}$
,, 29	$4\frac{13}{16}$	$8\frac{3}{8}$	5·74	$8\frac{3}{8}$	$7\frac{15}{16}$	$13\frac{3}{8}$
October 6	$4\frac{11}{16}$	$8\frac{1}{8}$	5·41	$8\frac{1}{8}$	$7\frac{13}{16}$	$13\frac{1}{4}$
,, 13	$4\frac{11}{16}$	8	5·32	$8\frac{1}{8}$	$7\frac{13}{16}$	$13\frac{1}{8}$
,, 20	$4\frac{11}{16}$	$8\frac{1}{8}$	5·42	$8\frac{1}{8}$	$7\frac{13}{16}$	$13\frac{3}{8}$
,, 27	$4\frac{13}{16}$	$8\frac{3}{8}$	5·71	$8\frac{3}{8}$	8	$13\frac{5}{8}$
November 3	$4\frac{13}{16}$	$8\frac{5}{8}$	5·91	$8\frac{5}{8}$	$8\frac{1}{4}$	$13\frac{7}{8}$
,, 10	$4\frac{15}{16}$	$8\frac{3}{4}$	6·16	$8\frac{7}{8}$	$8\frac{3}{8}$	$14\frac{1}{8}$
,, 17	$4\frac{13}{16}$	$8\frac{3}{4}$	5·93	$8\frac{7}{8}$	$8\frac{1}{4}$	$14\frac{1}{8}$
,, 24	$4\frac{13}{16}$	$8\frac{3}{4}$	6·11	9	$8\frac{1}{4}$	$14\frac{1}{8}$
December 1	$4\frac{7}{8}$	$8\frac{11}{16}$	6·16	$8\frac{7}{8}$	$8\frac{1}{4}$	$14\frac{3}{8}$
,, 8	5	9	6·42	$9\frac{1}{8}$	$8\frac{5}{16}$	$14\frac{5}{8}$
,, 15	$4\frac{7}{8}$	$8\frac{3}{4}$	6·29	$9\frac{1}{8}$	$8\frac{1}{4}$	$14\frac{5}{8}$
,, 22	$4\frac{15}{16}$	$8\frac{3}{4}$	6·31	9	$8\frac{1}{4}$	$14\frac{5}{8}$
,, 29	$4\frac{7}{8}$	$8\frac{11}{16}$	6·24	9	$8\frac{1}{4}$	$14\frac{5}{8}$
1906.						
January 5	$4\frac{13}{16}$	$8\frac{5}{8}$	6·23	9	$8\frac{3}{16}$	$14\frac{5}{8}$
,, 12	$4\frac{3}{4}$	$8\frac{1}{2}$	6·09	$8\frac{13}{16}$	$8\frac{3}{16}$	$14\frac{5}{8}$
,, 19	$4\frac{7}{8}$	$8\frac{5}{8}$	6·30	$8\frac{7}{8}$	$8\frac{1}{4}$	$14\frac{5}{8}$
,, 26	$4\frac{13}{16}$	$8\frac{5}{8}$	6·12	$8\frac{3}{4}$	$8\frac{3}{8}$	$14\frac{5}{8}$
February 2	$4\frac{3}{4}$	$8\frac{1}{2}$	5·99	$8\frac{3}{4}$	$8\frac{7}{16}$	$14\frac{7}{8}$
,, 9	$4\frac{3}{4}$	$8\frac{1}{2}$	5·87	$8\frac{3}{4}$	$8\frac{11}{16}$	$15\frac{1}{8}$
,, 16	$4\frac{3}{4}$	$8\frac{1}{2}$	5·91	$8\frac{5}{8}$	$8\frac{7}{8}$	$15\frac{3}{8}$
,, 23	$4\frac{3}{4}$	$8\frac{3}{8}$	5·73	$8\frac{5}{8}$	$8\frac{7}{8}$	$15\frac{3}{8}$
March 2	$4\frac{3}{4}$	$8\frac{5}{16}$	5·78	$8\frac{5}{8}$	$9\frac{1}{16}$	$15\frac{3}{8}$
,, 9	$4\frac{3}{4}$	$8\frac{5}{16}$	5·92	$8\frac{5}{8}$	$9\frac{3}{8}$	$15\frac{5}{8}$
,, 16	$4\frac{3}{4}$	$8\frac{5}{16}$	5·77	$8\frac{5}{8}$	$9\frac{1}{4}$	$15\frac{7}{8}$
,, 23	$4\frac{3}{4}$	$8\frac{1}{2}$	5·84	$8\frac{7}{8}$	$9\frac{5}{16}$	$16\frac{1}{8}$
,, 30	$4\frac{3}{4}$	$8\frac{5}{8}$	6·03	$8\frac{7}{8}$	$9\frac{1}{2}$	$15\frac{7}{8}$
April 6	$4\frac{13}{16}$	$8\frac{5}{8}$	6·10	9	$9\frac{13}{16}$	$16\frac{1}{8}$
,, 12	$4\frac{13}{16}$	$8\frac{5}{8}$	6·16	$9\frac{1}{8}$	$10\frac{1}{4}$	$16\frac{3}{8}$
,, 20	$4\frac{11}{16}$	$8\frac{5}{8}$	6·04	$9\frac{1}{8}$	$10\frac{3}{8}$	$16\frac{5}{8}$
,, 27	$4\frac{11}{16}$	$8\frac{11}{16}$	6·07	$9\frac{1}{8}$	$10\frac{3}{8}$	$16\frac{5}{8}$
May 4	$4\frac{11}{16}$	$8\frac{3}{4}$	6·08	9	$10\frac{1}{2}$	$16\frac{3}{8}$
,, 11	$4\frac{3}{4}$	$8\frac{3}{4}$	6·18	$9\frac{1}{8}$	$10\frac{1}{2}$	$16\frac{3}{8}$
,, 18	$4\frac{3}{4}$	$8\frac{13}{16}$	6·25	$9\frac{1}{8}$	$10\frac{1}{2}$	$16\frac{3}{8}$
,, 25	$4\frac{3}{4}$	$8\frac{7}{8}$	6·20	$9\frac{1}{4}$	$10\frac{1}{2}$	$16\frac{3}{8}$
June 1	$4\frac{3}{4}$	$8\frac{7}{8}$	6·02	$9\frac{1}{4}$	$10\frac{5}{8}$	$16\frac{3}{8}$
,, 8	$4\frac{11}{16}$	$8\frac{7}{8}$	6·01	$9\frac{1}{4}$	$10\frac{5}{8}$	$16\frac{3}{8}$
,, 15	$4\frac{11}{16}$	$8\frac{3}{4}$	6·07	$9\frac{3}{8}$	$10\frac{5}{8}$	$16\frac{1}{8}$
,, 22	$4\frac{11}{16}$	$8\frac{3}{4}$	6·12	$9\frac{3}{8}$	$10\frac{9}{16}$	$16\frac{1}{8}$
,, 29	$4\frac{3}{8}$	$8\frac{3}{4}$	6·10	$9\frac{3}{8}$	$10\frac{3}{8}$	$16\frac{1}{8}$

From the "Cotton Factory Times," June 29, 1906.

PRICE OF MEDIUM YARNS IN PENCE PER LB.

Count.	Weft.	Twist in cop.	Beam.	Bundle.	Twofold.	
					Bundle.	Cop.
4–16		$8\frac{1}{16}-9\frac{1}{16}$	—	—	—	—
10–28	8–9	—	—	—	—	—
20	—	$8\frac{3}{16}$	—	$8\frac{5}{8}-9\frac{5}{8}$	$9\frac{1}{4}-10\frac{3}{8}$	$9\frac{3}{16}-10\frac{5}{16}$
30	$8\frac{13}{16}-9\frac{9}{16}$	—	—	—	—	—
32	—	$9\frac{3}{16}-10\frac{1}{2}$	—	$9\frac{1}{2}-10\frac{1}{2}$	$10\frac{3}{8}-11\frac{3}{8}$	$10\frac{5}{16}-11\frac{5}{16}$
36	$9\frac{1}{16}-9\frac{11}{16}$	—	—	—	—	—
34	—	$9\frac{5}{16}-10\frac{5}{8}$	—	—	—	—
40	$9\frac{5}{16}-10$	$10\frac{5}{8}-11\frac{5}{8}$	—	$10\frac{1}{4}-11\frac{1}{4}$	$11\frac{1}{2}-12\frac{1}{2}$	$11\frac{3}{8}-12\frac{3}{8}$
50	$10\frac{11}{16}-11\frac{7}{16}$	$12\frac{1}{2}-13\frac{1}{2}$	—	$11\frac{1}{4}-12\frac{1}{8}$	$12\frac{9}{16}-14$	$13\frac{1}{2}-13\frac{3}{8}$
60	$12\frac{7}{8}-13\frac{7}{8}$	—	—	—	—	—
70	14–15	—	—	—	—	—
80	$17\frac{1}{4}-18\frac{1}{4}$	—	—	—	—	—
			EGYPTIAN YARNS.			
60	$15\frac{1}{2}-16\frac{1}{2}$	—	—	—	$17\frac{1}{2}-21$	$17\frac{3}{8}-20\frac{3}{4}$
70	$16\frac{3}{8}-17\frac{3}{8}$	—	—	—	$19\frac{1}{2}-24$	$19\frac{1}{4}-23\frac{1}{4}$
80	$17\frac{3}{8}-18\frac{3}{8}$	—	—	—	$21\frac{1}{2}-26\frac{3}{4}$	$21\frac{1}{4}-26\frac{1}{2}$
90	$18\frac{7}{8}-20\frac{3}{8}$	—	—	—	$23\frac{1}{2}-30$	$23\frac{1}{4}-29\frac{1}{2}$
100	$20\frac{3}{8}-22\frac{1}{8}$	—	—	—	$25\frac{3}{4}-33\frac{1}{4}$	$25\frac{1}{4}-32\frac{3}{4}$

Cotton, Official Quotations.
June 29, 1906.

American.

	G.O.	L.M.	Md.	G.M.	F.G.M.	M.F.
American	5·73	5·93	6·11	6·33	6·43	6·61

	M.F.	Fair.	G.F.
Pernam	5·78	6·18	6·44
Ceara	5·85	6·23	6·45
Paraiba	5·77	6·15	6·39
Maceio	*5·79	*6·17	*6·39

Egyptian.

	Fair.	G.F.	F.G.F.	Gd.
Egyptian, brown . .	$8\frac{3}{4}$	$9\frac{7}{8}$	$10\frac{3}{8}$	$11\frac{1}{8}$
Ditto, upper	$7\frac{15}{16}$	$8\frac{15}{16}$	$9\frac{5}{8}$	*$9\frac{7}{8}$

Egyptian, brown, fine, $11\frac{3}{4}$.
Ditto, upper, fine, *10.
Egyptian quotations do not refer to Bamia or Upper Egypt cotton.

* Nominal.

Indian.

	F.F.	G.F.	F.G.F.	Gd.	F.G.	Fine.
Broach	—	—	—	$5\frac{3}{8}$	$5\frac{17}{32}$	$5\frac{11}{16}$
Bhownuggar . . .	—	$*4\frac{3}{8}$	$*4\frac{1}{2}$	$*4\frac{5}{8}$	$*4\frac{3}{4}$	$*4\frac{7}{8}$
No. 1 Oomra . . .	—	$*4\frac{3}{8}$	$*4\frac{1}{2}$	$*4\frac{5}{8}$	$*4\frac{3}{4}$	$*4\frac{7}{8}$
Bengal	—	$3\frac{21}{32}$	$3\frac{25}{32}$	$3\frac{29}{32}$	$4\frac{1}{32}$	$4\frac{3}{16}$
Tinnivelly . . .	—	$5\frac{3}{16}$	$5\frac{3}{8}$	$5\frac{1}{2}$	—	

Bengal, Superfine, $4\frac{3}{8}$.

* Nominal.

The Costs of Power available at the Machines, in a Spinning Mill.

Basis: Engine and all plant connected therewith to develop 1000 I.H.P.

Engines, boilers, and economizers — Pumps and all the necessary connections—Shafting and rope-gearing—Reservoirs, land, buildings, and approaches at £15 per I.H.P. = £15,000.

Ratio of above costs—

(*a*) Engines, 35 per cent.

(*b*) Boilers and economizers, 20 per cent.

(*c*) Shafting and rope-gearing, 15 per cent.

(*d*) Reservoirs, land, buildings, and approaches, 30 per cent.

Working Expenses :—	£	*s.*	*d.*
Depreciation and upkeep inclusive on (*a*), (*b*), (*c*), at 10 per cent. per annum	1050	0	0
Depreciation and upkeep on (*d*), at $2\frac{1}{2}$ per cent. . . .	112	10	0
Interest at 4 per cent. per annum on (*a*), (*b*), (*c*), (*d*) . .	600	0	0
Stores at £0·25 per I.H.P. per annum.	250	0	0
Coals: 2 lbs. per I.H.P. per hour, at 7*s.* 6*d.* per ton . .	1476	0	0
Insurance (fire, accident), at 10*s.* per cent. on £12,000 .	60	0	0
Labour	400	0	0
	3948	10	0

Cost per I.H.P. per hour in pence (50 × 55 working hours)—

$$\frac{3948{\cdot}5 \times 240}{50 \times 55 \times 1000} = 0{\cdot}344$$

The inclusive power required in spinning mills, is about

1 I.H.P. per 63 spinning spindles in mills containing all mule spindles, and about 1 I.H.P. per 44 spinning spindles in mills containing all ring spinning spindles.

The power required to drive the various machines—

Hopper cotton pullers and feeders . .	1	I.H.P.	per machine
Simple Creighton opener	$2\frac{1}{2}$	,,	,,
Add: For each extra cylinder or beater	2	,,	,,
For each lap machine	2	,,	,,
For automatic feeders	1	,,	,,
For pneumatic cleaning trunks.	$1\frac{1}{2}$	,,	,,
Other types of openers as above.			
Scutchers, single with lap machine .	$3\frac{1}{2}$	,,	,,
Cards	1	,,	,,
Sliver lap	0·5	,,	,,
Ribbon lap	1·0	,,	,,
Comber, per combing head	0·1	,,	
Drawing frames, 5 dels. per	1	,,	
Slubbing frames, 45 spindles per . .	1	,,	
Intermediate frames, 60 spindles per .	1	,,	
Roving and ring frames, 80 spindles per	1	,,	
Mules, 110–120 spindles per	1	,,	

The Cost of Spaces in Spinning Mills.—This works out at about 2*s.* per square yard per annum, inclusive of lighting and rates.

The Extra Cost when the Process of Combing is introduced.—The productive capacity of a machine of the Heilmann type, as made by the principal makers, ranges from 300 to 500 lbs. per machine of eight heads.

In the following estimate moderate working conditions have been assumed, the production being taken at 400 lbs. per week of $55\frac{1}{2}$ hours per machine, and the waste extracted at 18 per cent.

The quantity of cotton required for treatment would therefore be $\frac{400 \times 100}{82} = 488$ lbs.

Assuming a wastage of $2\frac{1}{4}$ per cent. between the combing and carding stages, the amount of carded cotton required per 400 lbs. of combed would be 500 lbs. If a loss of 5 per cent. is

allowed for in the card, then $\frac{500 \times 100}{95}$ = weight of cotton required in card laps, 527 lbs.

And if 5 per cent. loss be allowed for in opening and scutching, then, $\frac{527 \times 100}{95}$ = 555 lbs. of raw cotton required per 400 lbs. of combed cotton.

When combing is not in vogue this amount would be less to the extent of

$$555 - \left(\frac{400 \times 100 \times 100}{95 \times 95}\right) = 555 - 444 = 111 \text{ lbs.}$$

Assuming the production of the card 350 lbs. per week, the extra carding machinery per 400 lbs. of combed sliver would be—

$$(500 - 400 = 100 \text{ lbs.}) = \frac{100}{350}$$

Taking the productive capacity of a scutcher at 8000 lbs., and that of the opener at 16,000 lbs. per week, respectively, the loss being 2 and 3 per cent. respectively, then the extra scutching and opening machinery would be—

$$\text{scutching, } \frac{106}{8000}\text{; opening, } \frac{109}{16000}$$

The extra labour involved, upon the following basis, would cost as follows :—

Cost of treating 16,000 *lbs. of scutched cotton.*

Mixing, opening and scutching, wages inclusive, £3 15*s.*

The cost, therefore, of treating the extra cotton required (106 lbs. scutcher lap) would be—

$$\frac{3{\cdot}75 \times 240 \times 106}{16000} = 5{\cdot}9d.$$

Therefore the extra cost on account of labour under this head would be—

$$\frac{5{\cdot}9}{400} = 0{\cdot}01475d. \text{ per pounds of combed cotton}$$

Taking the labour in carding at 28*s*. per 14 cards inclusive, the cost per pound of combed sliver would be—

$$\frac{28 \times 12 \times 100}{350 \times 14 \times 400} = 0{\cdot}01701d. \text{ per pound of combed sliver}$$

The costs of labour involved in preparing the cotton for and in combing:

One person, at 18*s*. per week, to attend the sliver and ribbon lap machines. Production, 2450 lbs. per week.

$$\frac{18 \times 12 \times 490}{2450 \times 400} = 0{\cdot}108d. \text{ per pound of combed cotton}$$

One person, at 20*s*., per six combing machines inclusive of cost of overlooking—

$$\frac{20 \times 12}{6 \times 400} = 0{\cdot}1d. \text{ per pound of combed sliver}$$

Other expenses:

Costs on account of the machinery—

	Approximate cost.	Proportional cost per combing machine.
	£	£
Cotton puller	140	0·92
Opener	300	1·97
Scutcher	180	2·36
Card	100	28·6
Silver lap	60	12·0
Ribbon lap	140	28·0
Comber	170	170·0
	Total	£243·85

Repair and upkeep at 7½ per cent. per annum on £243·85	= £18·289
Depreciation at 7½ per cent. per annum on £243·85	= 18·289
Interest at 5 per cent. per annum on £243·85	= 12·192
	£48·770

Cost, under this head, per pound of combed sliver $= \dfrac{48{\cdot}77 \times 240}{50 \times 400} = 0{\cdot}585d.$

Extra stock of cotton in process through combing, say 400 lbs. per combing machine of 8 heads.

Value of this at 8*d* per lb. = £13·3.

Interest on £13·3 at 5 per cent. per annum = £0·665

$$\text{Therefore cost per pound of combed sliver} = \frac{0{\cdot}665 \times 240}{50 \times 400} = 0{\cdot}008$$

Extra cost on account of space, at 2*s*. per square yard per annum—

				Proportional area: square yards.
Space per combing machine	(400 lbs.),	15	square yards	= 15·0
,, ribbon lap ,,	(2450 lbs.),	15	,,	= 2·5
,, sliver ,,		12	,,	= 2·0
				19·5

$$\text{Cost per pound of combed sliver} = \frac{19{\cdot}5 \times 2 \times 12}{50 \times 400} = 0{\cdot}0234d.$$

Extra cost on account of power, at 0·344*d*. per I.H.P. per hour—

		Proportional power.
Comber (400 lbs.)	$\frac{3}{4}$ I.H.P.	0·75
Ribbon lap machine (2450 lbs.)	1 ,,	0·25
Sliver ,, ,,	$\frac{1}{2}$,,	
		1·0

$$\frac{0{\cdot}344d. \times 55}{400} = 0{\cdot}0473d.$$

The extra cost on account of the waste extracted—

Waste at the combing stage, 88 lbs.

Extra waste at the previous stage, not returnable to mixing, 555 − 444 = 111 lbs.

Therefore 111 + 400 = 511 lbs. the amount of raw cotton required per 400 lbs. combed, and therefore the cost of the cotton per pound at the combing head on this account is—

$$\frac{8d. \times 511}{400} = 10{\cdot}22d. \text{ per pound}$$

Summary of Costs.

	Per pound of combed sliver.
Labour: On account of extra mixing, opening, and scutching .	0·01475
„ „ „ „ carding	0·01715
„ Preparing the comber lap	0·108
„ Combing	0·1
Machinery and upkeep, repairs, and stores	0·585
Extra stock of cotton	0·008
Space	0·0234
Power	0·0473
The total expenses nominally unaffected by changes in cotton values	0·9026
Value of the cotton at the combing head	10·22
	11·1226
Cost of raw cotton	8·0
Extra cost of combing (value of the waste reserved)	3·1226
Allow for value of the waste	1·0
Nett extra cost of combing	2·1226

80^s.—The cost of combing, when the raw cotton costs $11\frac{7}{8}d.$ per pound and the waste at this stage is 18 per cent., and 10 per cent. previous, allowing 50 per cent. of the cotton value for comber waste sold—

Value of the waste = 18 per cent. 1 lb. at $\frac{11\frac{7}{8}d.}{2} = 1{\cdot}07d.$ per pound

The extra waste made in scutching and carding will be worth about $2\frac{1}{2}$ per cent. of the cotton price per pound—

$$\frac{11\frac{7}{8}d. \times 2\frac{1}{2}}{100} = 0{\cdot}295d.$$

The cost of the cotton at the combing head is therefore

$$= \frac{11\frac{7}{8} \times 100}{72} = 16{\cdot}4d.$$

The cost of spinning 80^s uncombed on the basis of 19 hanks produced per spindle (see p. 235)—

$$= \frac{1{\cdot}72 \times 80}{19} = 7{\cdot}25d.$$

The other expenses of combing—

0·9026$d.$ per pound

Hence, assuming the waste made at the comber is sold at a price per pound equal to half the cost price of the raw cotton, then the extra cost of combing in this case would be—

18 per cent., 1 lb. × $\frac{8}{2}d.$ = 0·72$d.$

The cost of combing = 11·1226 − 8·0 − 0·72 = 2·5026$d.$

per pound	11·1226
	10·22
The expenses exclusive of the loss in waste	0·9026$d.$
	10·22
	8·0
The cost on account of the waste extracted, assuming it has no value	2·22

Costs of 80[s] combed as per tabulated data on p. 235. The cost of combing and spinning when the raw cotton costs 11$\frac{7}{8}d.$ per pound.

The cost of spinning (uncombed) as per tabulated data on p. 235—

$$\frac{1{\cdot}72 \times 80}{19} = \overset{d.}{7{\cdot}25} \text{ per lb. of yarn}$$

The cost of the cotton at the combing head, through waste loss, neglecting value derived from sale	= 16·4	,,	,,
The expenses of combing, excluding waste	= 0·9026	,,	,,

Less the value of 18 per cent. waste made in combing (at half price of raw cotton per pound)	$= -1{\cdot}07$ per lb. of yarn.
Less the value of waste made prior to combing (at $2\frac{1}{2}$ per cent. on the raw cotton price)	$= -0{\cdot}295$,, ,,

Cost per pound of yarn = 23·1876*d.*

EXAMPLE of the method adopted in estimating the cost given below—

Carding: 850 lbs. per card—

	s. d.	Cost per pound of yarn spun.
Labour: 2*s.* 11*d.* per card, inclusive of overlooking and card head tenter	2 11	= 0·0432
Power: 1 H.P. per card at 0·34*d.* per hour	1 6·7	= 0·0220
Machinery: £100 per card, 10 per cent. for loss, depreciation, and upkeep	4 1	= 0·0576
Space: 10·58 square yards per card at 2*s.* per yard	0 5·18	= 0·0061
	8 11·88	0·1289

The cost at the drawing and subsequent stages is given per productive unit, on account of the wide range of variation in their production. In order, therefore, to estimate the cost per pound, the production per delivery or per spindle is required. The production can be ascertained in the manner explained in other parts of this book.

The Departmental Costs in Spinning Carded Qualities of Yarn.—In estimating these costs up-to-date conditions have been taken as the basis. The cost of space has been assessed at 2*s.* per square yard per annum, inclusive. But no allowance has been made for waste.

Mixing—Cotton and Waste Storage—Opening—Scutching—

	Cost in pence per pound of yarn spun.
Labour	0·027
Power	0·0255
Machinery	0·0144
Space	0·00317
	0·07007

Carding—

	Cost in pence per card per week.
Labour	35·0
Power	18·7
Machinery	49·0
Space	5·18
	107·88

Drawing—

	Cost in pence per delivery per week.
Labour	12·5
Power	3·75
Machinery	16·0
Space	0·76
	33·01

Fly Frames :

Slubber—

	Cost in pence per spindle per week.
Labour	3·25
Power	0·415
Machinery	0·87
Space	0·195
	4·730

Intermediate—

Labour	1·75
Power	0·31
Machinery	0·575
Space	0·1
	2·735

Roving—

Labour	0·88
Power	0·268
Machinery	0·4
Space	0·067
	1·615

Mules—

Labour	0·45
Power	0·156
Machinery	0·15
Space	0·075
	0·831

Rings—

	Cost in pence per spindle per week.
Labour	0·25
Power	0·235
Machinery	0·216
Space	0·029
	0·730

Twining—

Labour	0·66
Power	0·113
Machinery	0·12
Space	0·067
	0·960

In twining the waste and costs of steaming and unpacking and packing the yarn must be added.

The waste is sometimes a considerable addition to the cost.

Twice the labour cost should always more than cover all expenses.

Ring Doubling—

	Cost in pence per spindle per week.
Labour	0·5
Power	0·312
Machinery	0·25
Space	0·044
	1·106

Other expenses—namely, *waste*, travellers, grease, spindle banding, bobbins—are considerable. The "waste" should always be considered as a separate item; 0·25 is a reasonable allowance for the rest.

Doubling Winding, or Winding.—The production per spindle is considered good at 75 per cent. of the calculated without allowances.

The number of spindles attended by one person may be estimated from the rate the winder can piece up as follows: Assume the winder can piece up at the average rate of 12 ends per minute, and that in the course of unwinding each ring bobbin end breaks twice, allowing 25 per cent. for the spindles stopped through incidental breakages.

On this assumption the production per winder will be—

$$\frac{55 \text{ hrs.} \times 60 \text{ mins.} \times 12 \times \text{ounces contained on each bobbin}}{2 \times 16}$$

$$= \text{pounds per winder}$$

Number of spindles per winder

$$= \frac{\text{pounds per winder}}{75 \text{ per cent. calculated production per spindle}} + 25 \text{ per cent.}$$

A Method of Ascertaining the Production of Reels.—The production of 40-hank reels in 55 hours when worked at 250 revolutions of the swift per minute, allowing two stops per bobbin unwound, and 5 seconds for each stop, the bobbins containing 0·75 oz. of counts 20^s, the time lost in tying and doffing being 3 minutes.

The time taken to fill the reel (40 hanks) if no stoppages

$$= \frac{80 \times 7 \times 60}{250} \text{ seconds}$$

The number of stops in filling the reel

$$= \frac{840}{\frac{0·75}{16} \times 840 \times 20} \times 2$$

The time lost in filling the reel through stopping

$$= \frac{840}{\frac{0·75}{16} \times 840 \times 20} \times 2 \times 5 \times 40 \text{ seconds}$$

The time taken to fill and doff, allowing two stoppages per bobbin unwound

$$= \frac{80 \times 7 \times 60}{250} + \frac{840 \times 16 \times 2 \times 5 \times 40}{0·75 \times 840 \times 20} + 180$$

$$= 134·4 + 427 + 180 \text{ seconds} = 12·37 \text{ minutes}$$

The production per week in pounds

$$= \frac{55 \times 60}{12·37} \times 2 = 533 \text{ lbs.}$$

The weekly earnings of winders and reelers vary from 14*s.* to 24*s.* per week, and the cost per pound of yarn treated, varies, in this work, comparing districts, more than in any other section of the spinning mill.

The numerous departmental wage lists and the difference in these, in the various districts, do not admit of the costs in wages being treated, in a work of this kind, in any other manner than that adopted.

Although these lists differ on paper, competition has resulted in this difference in the costs—being that approaching the vanishing point, when reduced to a basis embodying quantity and quality of production.

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THE END

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